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ABSTRACT

This teaching guide is one of a series developed by the Curriculum Research and Development Group at the University of Hawaii. The program is laboratory and field oriented for elementary students. The focus of study for the project is the plant and animal life and the physical components of the Hawaiian environment, and their ecological relationships. The program stresses student on-site observations, experimentation, discussion, and learning by experience. It is designed to fit within the science curriculum but can correlate with other subject areas in school, as well as with local community interests. This particular guide book is divided into four sections: (1) Getting Started; (2) Equipment and Skills Needed for Investigating Insects; (3) Insect Investigations; and (4) Metamorphosis, Anatomy, Classification. Each section is then subdivided into topics and activities. There are numerous illustrations and charts that can be used by the classroom teacher. The guide also contains background information, problems to be studied, suggestions for conducting observations and experiments, optional vocabulary lists, and suggested correlations with other disciplines. This series also includes a program manual that gives additional information on the use of this nature study program. (Author/MA)

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HAWAII NATURE STUDY PROGRAM

FOR ELEMENTARY SCHOOL CHILDREN

INSECTS

Teacher's Guide

SE 023 245

A project of

CURRICULUM RESEARCH AND DEVELOPMENT GROUP
University Laboratory School
UNIVERSITY OF HAWAII
1776 University Avenue
Honolulu, Hawaii 96822

INSECTS

HAWAII NATURE STUDY PROJECT

by the

CURRICULUM RESEARCH AND DEVELOPMENT GROUP

UNIVERSITY OF HAWAII

Assisted by the HAWAIIAN ACADEMY OF SCIENCE

and other friends of the Project

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THE HAWAII NATURE STUDY PROGRAM

The Hawaii Nature Study Program is a laboratory- and field-oriented program for elementary students. The focus of study is the plant and animal life and the physical components of the Hawaiian environment, and their ecological relationships. The program stresses student on-site observations, experimentation, discussion, and learning by experience.

The Hawaii Nature Study Program is designed to fit within the science curriculum but it correlates with other subject areas in school as well as with local community interests. It promotes awareness, appreciation, knowledge, and understanding of the environment. The specific skills it developes prepares students for science courses in the intermediate school.

The PROGRAM MANUAL, separately bound, contains a complete description of the program and its goals, together with an explanation of the BAND levels, suggested teaching strategies, and general directions on how to handle campus investigations, data analyses, and student reports.

Before putting this booklet of activities on INSECTS into classroom use, a teacher needs to become well acquainted with the contents of the PROGRAM MANUAL. Order as a separate item from the project office. See front cover for address.

INTRODUCTION TO INSECTS

If you were 8 years old again, had never studied entomology, but had watched various Disney and other nature movies, what might you contribute to a discussion about insects? You may have bits of information about tall termite mounds in South Africa, great beetles in the South Pacific, or the fantastically colored butterflies of South America. But what of the insects in your own backyard? Those are usually a great unknown. This booklet on INSECTS provides teaching materials for exploring insects which live in that great unknown but important world of our own campuses and neighborhoods.

Content of Teacher's Guide

INSECTS contains background information for the teacher, problems to be investigated, suggestions for carrying out observations and experiments, optional vocabulary lists, suggested correlations with art, music, mathematics, social studies, and reminders to have the students keep data and make reports as explained in the PROGRAM MANUAL.

Scope

This study on insects is directed to drawing attention to their existence, appreciating their forms and their various behaviors, getting to know something about them from direct observation and elementary-level investigation.

"Insects" is not a reduction of the content found in the standard texts. A scan of the entomology books on library shelves reveals remarkable agreement on what scholars consider fundamental to the discipline. Almost every Chapter One or Introduction explains, reviews, or at least assumes, information about typical insect anatomy, metamorphosis, and the classification of insects in Orders based on standard criteria. Yet these fundamentals are far from elementary. They are the fruit of centuries of observations and of intensive scientific effort. They are not phenomena strikingly obvious to a beginning observer. Untutored logic is on the side of the 5th grader who kept throwing out the maggots which somehow got into and contaminated the cage in which she was trying to hatch fly eggs and raise baby flies. Armed only with youthful inexperience, who could guess that such diverse forms as a grub and a beetle belong together; whereas a termite and a larva, both white and worm-like, are classified in different Orders? What beginner could surmise, when confronted with a maze of caterpillars, cockroaches, inch worms, and what not else, that "insects are characterized by 3 body regions, 6 legs, and 4 wings?"

This elementary nature study series on insects builds on amateur observation and investigation of insects in the local neighborhood using unbiased and untutored eyes, ears, and fingers; overlooking for the moment the technical information to come in standard courses in later years.

Time

The amount of time within the school year and the length of class periods to devote to insect study is entirely flexible. The right time in the school year for a teacher to begin insect study in Hawaii stretches from September to June. Student interest may be sustained over many weeks, or it may flicker out in a few days. Planning is to be recommended, but when student interest peaks or flags, or when a special living insect happens to be available, expediency may take precedence over the best planning.

Sequence

A teacher is encouraged to select as few or as many of the insect investigations offered in this book as fit the neighborhood potential and the students' ability levels. The order in which the investigations are done is likewise entirely up to the teacher who is in a position to interpret student interest.

The investigations in this book are presented in a sequence appropriate to using direct raw observation as the initial point of inquiry.

First comes a survey of the local area to inventory what is available for study.

The second section considers the equipment and skills needed for plunging into investigations on specific insects.

Section three is a catalog on insect investigations from which can be selected as many or as few tasks as desired and in any order.

Section four goes lightly into metamorphosis, insect anatomy, and classification. These topics are placed last because only after students have observed a number of insects are they in a position to contribute from their own experience to a discussion about the varieties of insect body types and behaviors.

INSECTS

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SECTION 1. GETTING STARTED

1. INSECT SAFARI

Introduction

If this elementary study of insects is to be based on observations made in the school neighborhood as claimed in the foreword, then the first exercise had better be to get out into the local environment and take a look.

The lesson can begin with a drawing out of what the students already know (and do not know) about insects, followed by a sallying forth to see what might be found outside.

Problem:

What insects live in our neighborhood?

Materials

-*Notebooks*
-*Plastic baggies*

Procedures-in-Brief

1. Stir up some interest and student questions about insects. Initiate interest in finding out what kinds may be available for study in the school and home neighborhood.

2. Go on an "insect safari." Use a class period, possibly with an extension into homework, to canvass the neighborhood.

3. Talk about the findings. Make a list of insects found. The list can be used to select insects for special study.

Procedures-in-Detail

1. Stir up some interest.
   Here are a few questions which can be selected from, or enlarged upon, to whatever extent seems useful for motivating the observation tour.

   -What is an insect? (Do not answer this question. Let the students drown, for the time being, in their own misconceptions.)

   -Do any insects live in our school yard? What kinds? Have you seen any?

-Where to they live?

-How big is the biggest insect? (For a "Wow" reaction you might offer that the world's largest insects are said to be the Goliath beetle of Africa which is 6" long (Ask how long that is.), a walking stick insect of the Malay Peninsula at 13"; and the Atlas Moth of Australia with a wing span up to 14".)

-What is the smallest insect? (Various species smaller than pin heads.)

-Do insects bite? Are they poisonous? Is it safe to pick one up? (If some students show strong negative reaction to touching some kinds of insects do not force the issue. Keep a cool, detached attitude yourself. By the time the students have raised a few insects from babyhood they will be treating them like cherished jewels.)

-Would we find any insects in our yard in the daytime?

-Where could we look? Where might they be hiding?

-Could we catch them? (We could; but only to look at and then release again. We will need cages before we catch them to keep.)

-Do you know what a safari is? (African big game hunt, with gun or camera.)

We could have an insect safari on our campus. It will tell us something about the kinds and numbers of insects we have in our neighborhood.

2. Go on an insect safari.

First lay down a few ground rules, such as that this is a search-and-observe mission. It is not a search-and-destroy, not a search-and-seize, and not a search-and-tease safari.

Divide into groups.

Assign search areas to each group. Division could be made geographically, having each group look at everything in its part of the campus; or division of labor could be made by kinds of places to search, such as one group searches hedges, another group searches surface soil, another looks for flyers, etc.

Older students should bring notebooks in which to enter a sketch of the kinds of insects found or a very brief description of them together with where they were seen.

Sample specimens can be put into plastic baggies for "show and tell" at the end of the safari, if desired. Specimens will be released again afterwards.

The safari might take one class period; or one class period plus homework in order to include home and neighborhood areas in the search.

The safari could be repeated a few days or a few weeks later, if desired. After the students have worked with a few insects they become more alert to seeing others. Also, safaris at different times of day or at different seasons (rainy or dry) can yield different results.

3. Report results.

Any reporting system or listing of insects which lays groundwork for further campus work or classroom investigation is a desireable method.

Reporting can take the form of general conversation while sitting on the lawn; or by group reports back in the classroom.

There might be a "show and tell" of insects brought back in the plastic baggies, accompanied by a description of the kind of area in which each was found.

This may be a good time to start the science notebooks. Construct a data table showing what insects were found (identified by sketch or a brief phrase if the name is not known) and where they were found (under the building, in weeds behind gym, etc.)

Discuss which kinds of insects were seen most often or in greatest abundance. Take note of their methods of locomotion and possible ease for catching, keeping, and caring for.

Correlations

Jim McClain of Hanahauoli School has for years been taking his youngsters on a "Safari for Creepy Crawlers." He includes all campus invertebrates in his tour. For "guns" his students use hand lenses. A good story either to precede or follow the safari is "All Upon a Stone," by Jean Craighead George, published by Thomas Cromwell of New York in 1971.

After discussion of their "creepy crawlers," the students are encouraged to write stories or poems about them. Lyrics can be written to popular tunes. For example, using the melody of "If I were a rich man..." from Fiddler on the Roof, sing "If I were a stink bug. Tra-la-la-la...etc." Other melodies can be used also.

2. WHERE DO WE GO FROM HERE?

Introduction

"Where do we go from here?" makes a good class discussion topic for a group of students who are accustomed to taking some hand in their own destiny. If they have not had practice in shared decision making, this may be a time to begin.

The problem of which insects to study in greater detail may already have been determined by the reactions to the reports on the safari, so that there is no need to discuss the issue. If the class interest was caught by one particular insect found on the campus, you may decide to move directly to an investigation of that species without bringing up the question which constitutes this topic.

If the safari failed to stimulate any interest, you may need to supply further motivation. Perhaps you might bring a grasshopper to school, or some singing crickets in a cage, or take on the personal care of some Monarch pupae up to the time they emerge as butterflies, to see if interest is awakened toward these. An alternative is to change to a study of birds, or dinosaurs, or space travel. Try insects again next semester.

The common student response to the safari is a desire to bring in all the insects right now and collect 157 varieties to observe all at once starting today. In that case, the question "What insects shall we do first?" becomes useful as a sorting mechanism. It serves as a brake against getting into too many things simultaneously.

Problem:

What insects from our list shall we study first?

Materials

-*Notes from the safari*

Procedures

1. From the list of insects made during the safari, try to find one or a few for special observation and study. Choose those which are abundant in the area, reasonably easy to care for, and interesting to the students.

   If the class cannot come to an agreement on which particular insect(s) to study, it might help to sort them into groups. For example, insects may be grouped as flyers, crawlers, ground-livers, pond-dwellers, and other types. Put together kinds which look as if they may require similar types of cages or care.

If the class has some previous experience in laboratory responsibilities several insects may be studied at once with the labor and investigations divided among different small groups in the class.

2. Working with the class, decide which insect or which group of insects to start to study. Glance through Section 3 of this book and look over some problems which could be worked on. Perhaps one of the investigations described in Section 3 fits one of the insects found on the campus.

3. Consult Section 2 for equipment and skills needed to prepare for and handle the insect(s) chosen.

4. Consult the PROGRAM MANUAL for strategies in getting the investigations underway and for handling student reports.

Games and word puzzles often fascinate young students. A few few brain teasers have been inserted as fillers wherever blank space occurred after the pages were typed. The puzzles all refer to the general subject of INSECTS but do not necessarily fit the topic of BAND level they accompany. They are set apart from the text by a dotted border.

Insect Cryptoquiz

The groups of code letters below are each the name of an insect. Crack the code by looking for familiar patterns of repeated or double letters. Although the words are not connected in a sentence, they all follow the same code, i.e. if a G stands for H in one insect name, (which it does not in this case) then G will stand for H in all the other insect names. Answers on page 50.

D P D L S P B D I F T

C F F T

D S J D L F U T

T J M W F S G J T I

C V U U F S G M J F T

W P U I T

N P T R V J U P F T

M B E J - C J S E C F F U M F T

B O U T

D B E E J T G M J F T

G M J F T

Q S B Z J O H N B O U J T

3. WHAT SHALL WE DO WITH THIS INSECT?

Introduction

Managing a neighborhood insect study requires a few qualities on the part of an elementary teacher which are not usually included in the repertoire of research scientists. An entomologist usually knows, or can find out from the literature, what particular insect is useful in his field of research. Such luxuries are not granted to the elementary teacher.

A teacher is more likely to be confronted with a "queer looking" insect brought in by an eager child and to have to face the question, "What shall we do with this?" It helps, of course, if the teacher knows the names and potential uses of every insect the youngsters bring in. But such expertise is not really necessary at the level at which insects are studied in the elementary grades.

What an elementary teacher needs more than scientific expertise is boundless courage to take on almost anything the students bring; an imagination to figure out something to do with the "critter" (putting it in a cage and watching it is usually a safe start); and the patience not to be discouraged, if something does not work out. Not everything will work when such an open door policy is practiced.

It is almost impossible to list procedures on how to handle whichever of such situations arise. What might help somewhat is seeing what other teachers do. Below are two inspiring examples.

Example 1. Baby Cockroaches, Unlimited

Dorothy Buddemier of Kamiloiki School enjoyed the good fortune of having her children discover an old shed which had been closed up for some months. When the room was opened, myriads of cockroaches scurried away in all directions, leaving behind dozens of brown cockroach egg purses on shelves and in corners. The class helped to plan a "Cockroach Egg Purse Project." The brown egg cases were gathered up and placed in cages (jars with sand on the bottom and screen covers). While daily lessons went on, the cockroach purses rested in their cages, their dates of laying and expected hatching time unknown. Some cages were placed in the light, and some were kept in the dark; some had moist sponges in the jar and some were kept dry. Periodically they were inspected to see if any changes were occurring.

Within a few weeks, first one and then another of the purses began to break open and out came hundreds of very tiny cockroaches. The children exclaimed chiefly about their tiny size and the speed at which such newborn creatures could run. Also discussed was their color, shape, resemblance to adults, how many per purse, and finally what to do with them. Some were fed to the classroom chameleon. Some were kept caged and fed

on different foods and were watched to grow. The children seemed not to object to destroying excess numbers.

Dorothy had evidently failed to read the advice printed in temperate zone texts warning against trying to raise cockroaches because their life cycle is too long. It takes as much as a year for some egg cases to hatch. Without that advice, this project in a warm tropical zone, went ahead to success in a few weeks.

Example 2. Cocoons and Crysalides

Yvonne Toma at Kipapa Elementary School planned a Monarch Butterfly project for her second graders. She began by sending them out to collect the striped Monarch caterpillars and pupae from crown flower bushes in their home neighborhoods. Given a chance to bring caterpillars to school, no second grader is going to be confined to contributing only a few striped Monarchs. "Everything" came in: worms, green caterpillars, inchworms, cocoons, pupa cases of more kinds than Yvonne could begin to identify. The worms went back outside. The various cocoons and pupa cases were put into cages and a waiting game began while other lessons went on. Some of the cases opened into Monarchs, some opened into big black witch moths; some into other things no one knew a name for; and some did not open at all.

The second graders admired their pets, drew pictures of them, and wrote stories about them. Eventually the captives were turned loose and the cages were cleaned for the next project.

Example 3 will be the story YOU send in to be an inspiration for teachers who will read the next edition of this book. Both Dorothy and Yvonne are primary teachers. What do you upper elementary teachers do?

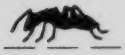
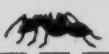
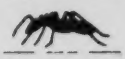
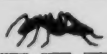
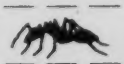
Can you change a PUPA into a MOTH in nine "instars"? Change one letter at a time to form a new word at each change until the moth emerges.

(One possible answer: PUPA - PUPS - PUTS - PATS - OATS - OATH - BATH - BOTH - MOTH)

Answers to puzzle on next page: CANT, RANT, PANT, ANTI, WANT, GIANT, GRANT, PLANT, SANTA, SLANT, TRUANT, BANTER, CHANTS, INFANT, LANTERN, ANTENNA, ANTIQUE, DORMANT, ADAMANT, ANTIPODE, GIGANTIC, ANTELOPE, ADVANTAGE, REDUNDANT, PLANTATION.

WORD ANTHILL

This "anthill" contains 25 ANTS. The picture of the ant stands for the three letters A N T, in that order. Can you put letters before and after the ANT to make the word indicated by the definitions?
Example: A charming person is _E N C H_ _I N G_

1. Unable to do: _ _ _ _
2. Rave: _ _ _ _
3. Breathe quickly: _ _ _ _
4. Against: _ _ _ _
5. Desire or need: _ _ _ _
6. Very large: _ _ _ _ _
7. Give permission: _ _  _ _
8. Put seed into ground: _ _ _ _
9. He brings toys at Christmas: _ _ _ _
10. Tilt: _ _ _ _
11. Hookey player: _ _ _ _ _ _
12. Teasing: _ _ _ _ _ _
13. Sings on one or two notes: _ _ _ _ _ _
14. Tiny child: _ _ _ _ _ _
15. Light for carrying: _ _ _ _ _ _ _
16. An insect feeler: _ _ _ _ _ _ _
17. Very old: _ _ _ _ _ _ _
18. Asleep: _ _ _ _ _ _ _
19. Hard and Firm: _ _ _ _  _ _ _
20. Botswana to Hawaii:  _ _ _ _ _ _ _
21. Enormous: _ _ _  _ _ _ _ _
22. Fast running animal: _ _ _ _ _ _ _
23. Have the upper hand: _ _ _ _ _ _ _ _
24. Repetition: _ _ _ _ _ _  _ _ _
25. Large farm: _ _ _ _ _ _ _ _ _ _

SECTION 2. EQUIPMENT AND SKILLS NEEDED FOR INVESTIGATING INSECTS

Most elementary insect investigations can be carried out using a few kinds of basic equipment. These are described in this section.

The nets, traps, cages, and feeding methods described here are not an experiment. This is a reference section which can be looked over, kept in mind, referred to, and used as the information is needed during the insect investigations.

The descriptions here are sketchy but are probably sufficient for most elementary needs. Specialized materials and methods needed for specific insects are described with those insects in Section 3.

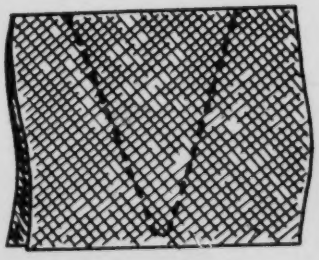
Each type of cage or method of insect care in this section is given a number by which it may be referred to from other places.

1. NETS, TRAPS, CAGES

NETS

10. SWEEP NETS.

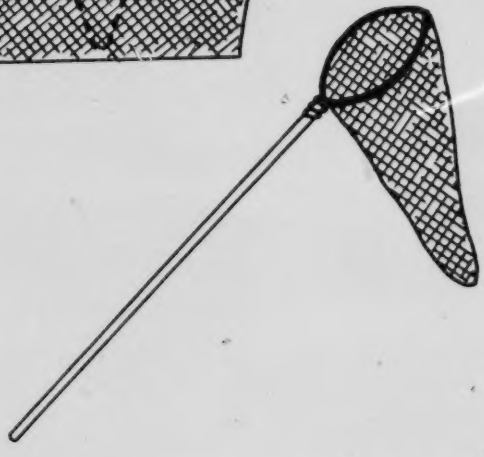
Open a wire coat hanger to form a circle. Attach a long handle.



Make a cone-shaped net from mesh fabric and sew it to the wire circle.

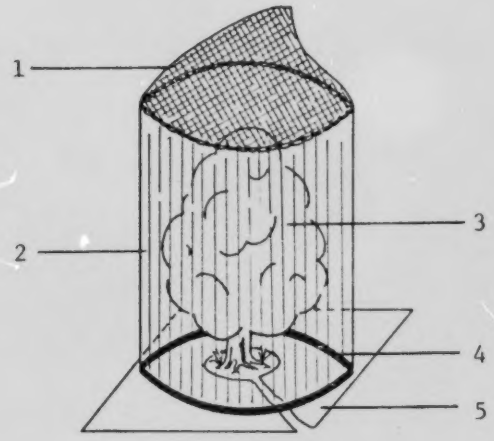
In using the net, do not dash about swiping at every passing butterfly. Walk along brushing the net in even strokes over the tops of grass or shrubbery.

11. BUSH BAG NET.



Begin with a large cylinder of dark fabric which will fit around a bush. Enclose the top of the cylinder with a cone-shaped transparent net. Make the bottom of the dark fabric firm by attaching it to a wooden frame or a hula hoop.

To use the net, first spread a canvas or old sheet carefully under a bush, disturbing the bush as little as possible. Then quickly clap the Bag Net over the top of the bush, covering it entirely. When insects in bushes are disturbed, some of them drop to the ground. These can be collected afterwards from the canvas. Other insects fly upwards to the light and are caught in the net at the top.



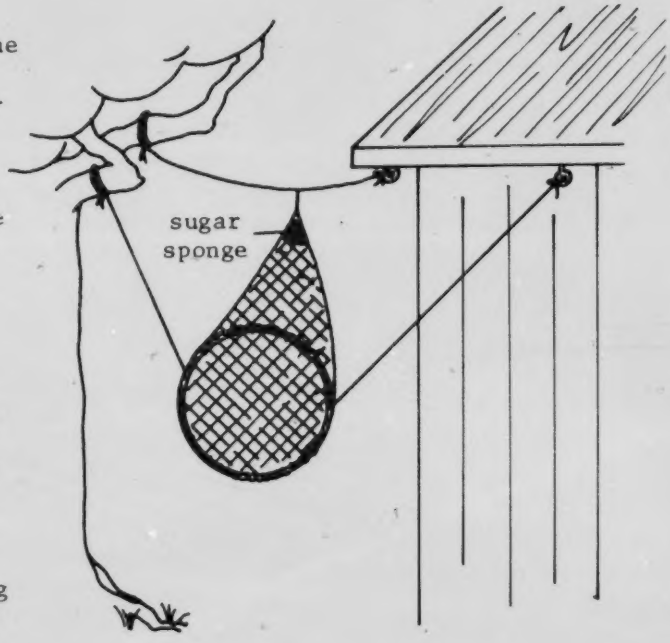
1 = sheer net dome
2 = dark fabric bag
3 = covered bush
4 = stiff frame attached to fabric bag
5 = canvas spread on ground below bush

12. AIRWAYS NET.

Construct a large cone of transparent nylon or pale green net. Fasten a sponge saturated with sugar in the tip of the cone.

Hold the large opening of the net open by a square wooden frame or a hula hoop.

Hang the net between buildings or trees where breezes sweep through, with the tip of the cone held up higher than the large opening. Insects are often carried along by the winds in air passageways. As the insects enter the cone and hit the net, they tend to crawl upwards. The sugary sponge at the tip of the cone encourages them to stay until you can collect them.



13. WATER SEINE.

Use a small tea strainer to dip up insects or polywogs from small shallow ponds.

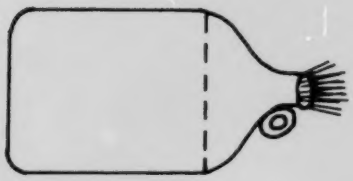
In larger ponds, use a larger wire mesh strainer such as are used in kitchens. Attach a long handle.

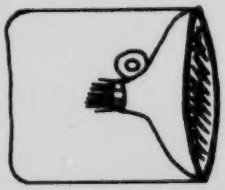
TRAPS

20. ONE-WAY-IN-TRAP.

To the narrow mouth of a gallon plastic jug, attach wires pointing outwards.

Cut off the top of the jug, turn it around, and insert it into the body of the jug. Fasten tightly around the edges with masking tape.



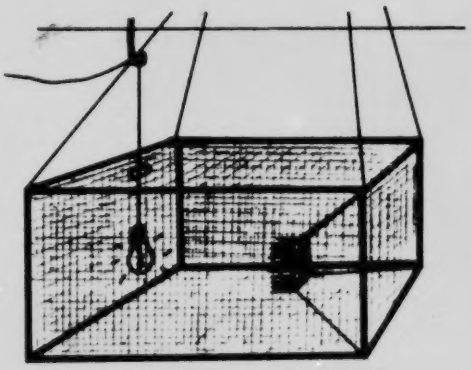


After insects enter through the opening, they cannot get out again because of the wires poking at them around the opening.

Bait the trap with food having an odor. The trap may be hung in the air from a tree limb to catch flying insects, or placed on the ground to catch crawlers.

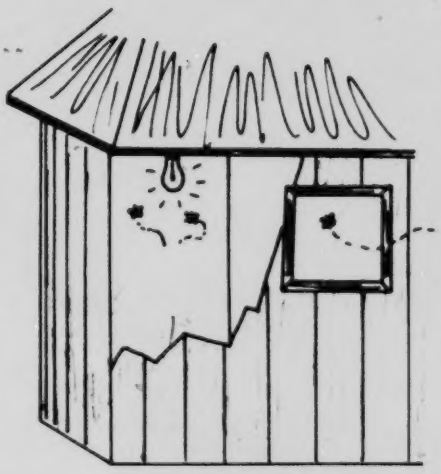
21. LIGHT TRAP.

Construct a screen cage, any size, any shape. On one side, insert a small opening with wires pointing inwards so that after an insect enters the cage it has difficulty getting out again.



Hang a light bulb in the cage at the side opposite the opening.

Suspend the cage at night from the edge of the roof or ceiling of the lanai.



22. THE OPEN ROOM.

Open one window of a room and remove the screen. Close all other windows and doors of the room. Turn on the light (at night, of course) and see what flies into the room seeking the light.

23. LIGHT AND WATER TRAP.

Under a ceiling light or lamp on the lanai at night, place a shiny aluminum pie tin filled with water. Insects which fly to the light, see a second light reflected in the water and dive into it. Fish them out before they drown and place them in a dry cage.

24. HAND PICK.

Stationary or slow crawling insects can be picked up in the fingers or with an instrument handled gently.

25. PIT FALL.

Bury a large coffee tin or gallon glass jar in the ground with its open top just below the ground level. Pack the soil closely around the container so that insects crawling along will fall into the container.

Support a board on a few stones above the top of the trap to keep out rain and larger animals (including two legged ones.)

Bait the trap with food having an odor. Insects which fall in during the night cannot usually climb up the slippery sides of the container before you harvest them the following morning.

26. SUGARING.

Catching insects by "sugaring" was discovered accidentally in 1832 in England when an empty sugar cask was left outside and was found to be attractive to moths in great numbers.

Prepare a "paint," following one of the recipes shown below or make up a similar thick fermented sugar mixture.

With a paint brush, smear a heavy coating of the sugaring "paint" on a fence post or tree trunk at a convenient height. Within an hour many insects will come to the painted spot where they can be harvested

in a net or by hand.

A productive time for painting is at dusk. Sugaring may also be done in the daytime or at night to collect insects active at different times.

Recipes for Paint Used in Sugaring:

1. Crush a ripe banana and let it ferment for a day. Add an equal amount of molasses. Mix in a small amount of beer to the consistency of a thick paint.

2. Use thick molasses as it is, or mixed with a small amount of fermented fruit juice.

3. Boil syrup or sugar solution until it becomes thick. Add beer or fermented fruit juices.

4. The original recipe used in England was to boil together a mixture of brown sugar and beer until it became thick. Then mix in a small portion of rum.

27. COMMERCIAL TRAPS.

Commercial traps are very effective in catching insects, but since they usually kill the insects in the process they are not useful for collecting live specimens.

CAGES

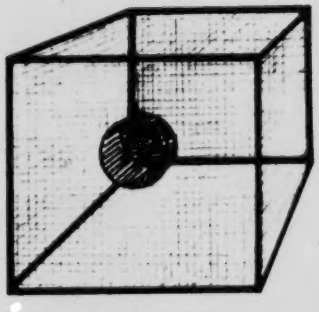
30. GLASS JAR CAGE.

Use a glass jar, any size, preferably having a wide mouth. Cover the opening with a piece of nylon stocking or other mesh, stretched tightly, and held down by a strong rubber band.

Cover the bottom with a paper towel or clean sand to give traction for walking or crawling.

31. SCREEN CAGE.

Make a stiff open frame of wood or wire. It may be any shape or size, such as a cube or an elongated shape.

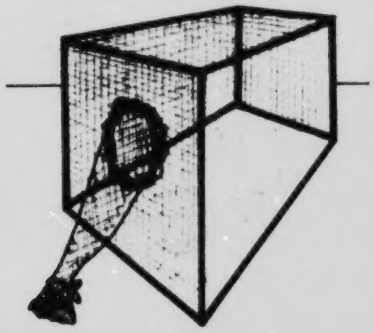


Cover four sides with screening or mesh or net.

Have one side of glass or plastic to permit clear viewing.

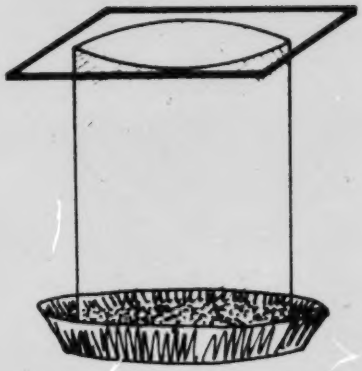
Make a hole in one side for getting a hand or arm in and out. The hole may be kept closed by a paper poi bowl, or it may be fitted with a fabric sleeve.

A fabric sleeve is a nylon stocking or some other light fabric tube fastened around the edge of the opening and extending outwards from the cage. When not being used, the sleeve is tied shut. To get into the cage, insert the hand and arm through the sleeve opening.



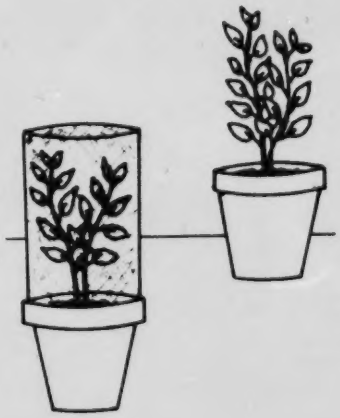
32. CYLINDER CAGE.

Roll a rectangular piece of screening into a cylinder. Anchor the bottom opening of the cylinder to a wooden board, to cardboard, or sink it into a shallow pan of sand. Cover the top opening of the cylinder with a glass pane.



33. FLOWER POT CAGES.

If the insect being kept has a preference for a particular type of plant, grow several of the plants in a series of flower pots of the same size. Make a screen dome of a size to fit the outer rim of the flower pot. When the insects have eaten or otherwise messed up one plant, move the dome and insects to the next potted plant.

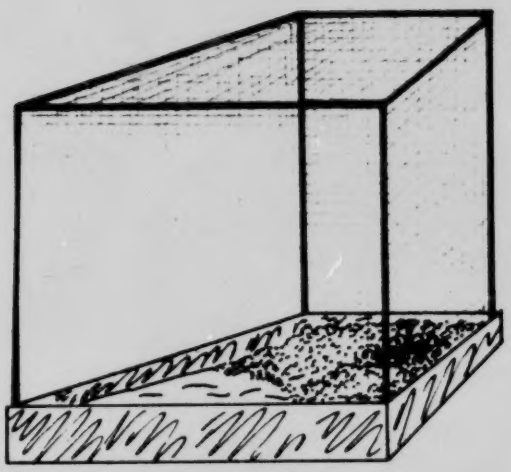


34. OLD AQUARIUM.

An old aquarium, or other large container, can be made into a cage by fitting a screen securely over the top.

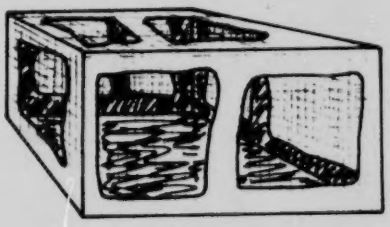
35. POND CAGE.

For insects which require open water for part of their life cycle, use a large flat plastic pan. Put soil or sand or moss at one end and leave the other end as a small pond. Cover the top with a large dome of screening.

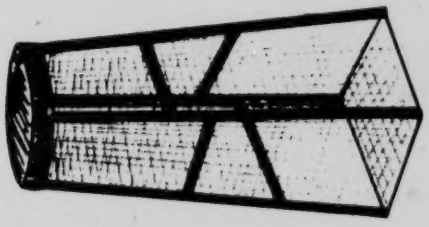


36. INVENTOR'S DELIGHT.

An Inventor's Delight is a usable cage put together by an imaginative student using whatever material can be scrounged from anywhere.



Cardboard box with holes cut out and entirely covered with mesh.



Stool with legs covered with screen.

Some classes may enjoy having an insect cage making contest. Points could be given for:

-cost of raw materials (free junk gets the highest score)
-suitability of cage for a given insect
-ease in cleaning and providing food and water
-neatness and appearance
-originality
-other criteria you may wish to specify

OTHER EQUIPMENT

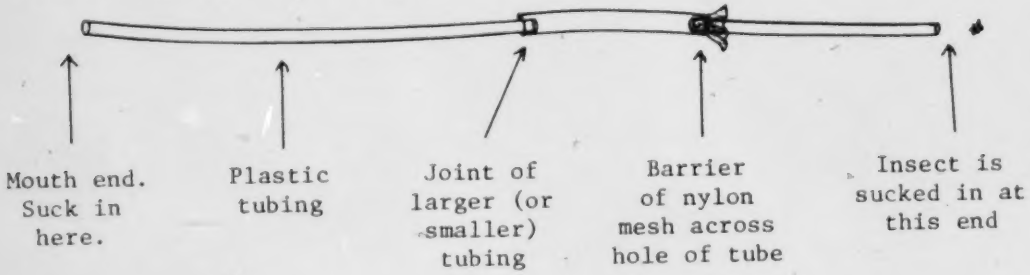
40. HOLDING JAR.

A holding jar is usually a gallon container with a wide mouth. The opening is fitted with a nylon stocking or sleeve of fabric.

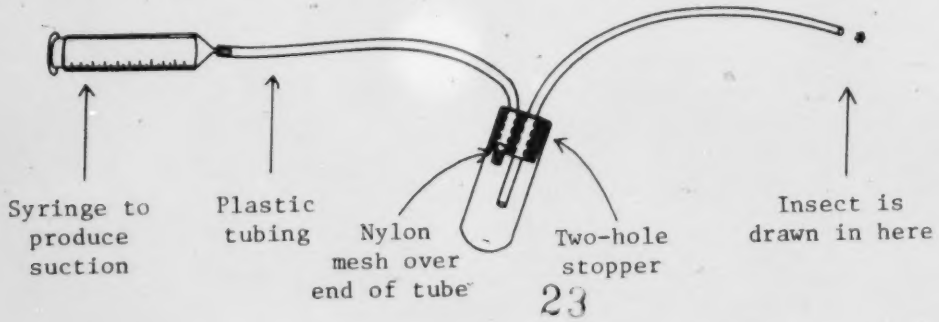
When insects are collected in the field they can be put into the holding jar and brought back to the classroom where cages are ready to receive them.

41. ASPIRATORS.

An aspirator is a tube-shaped device into which very small insects can be sucked. The simplest aspirator is two pieces of tubing, such as fish tank tubing, joined together. A plug of gauze or net is inserted where the two pieces of tubing are joined together. The plug of netting allows air to be sucked through the tube but prevents the insect from going all the way through the tube and into the mouth which is doing the sucking.


Mouth end. Suck in here.
Plastic tubing
Joint of larger (or smaller) tubing
Barrier of nylon mesh across hole of tube
Insect is sucked in at this end

A variation of the aspirator can be made using a large 50-cc syringe and a small bottle with a two-hole stopper. It takes two people to operate this style of aspirator; one to pull the plunger of the syringe and the other to aim the tubing at the moving insect.



The students may wish to invent further variations of the aspirator.

It will be noticed that when the tubing used is larger, the suction power becomes less until there is not enough to pull an insect into the tube. Hence to get enough suction power, small bore tubing is needed, which means that only small insects can be suctioned in.

42. INSECT PRESERVATION.

Making a shelf collection of preserved insects is not a highly recommended activity for elementary students. Entomologists keep large, valuable insect collections for study and identification purposes. But elementary students acquire most of the value from their insects by observing them while they are alive or examining them when recently dead. Classroom shelves of preserved insects take up valuable classroom space, are seldom looked at, and even less seldom learned from. An exception might be a specimen of unusual rarity or size or interest.

In those cases in which preservation of insect specimens seems justified, the following methods can be used.

Pinned Insects.

Use a cigar box or similar container. Cut a piece of cardboard to fit the bottom of the box into which it is easy to stick a pin or needle. With an insect pin or a very thin sewing needle, pierce the body of the insect slightly to one side of the middle. Put the insect up at the eye end of the needle while the point of the needle is stuck into the floor of the box. Pin or paste a label at the bottom of the insect pin. Very tiny insects can be glued to a small triangle of paper and the needle can be put through the paper triangle.

As a preservative, anchor a few moth balls or moth crystals into a corner of the box.

Cotton Bedding.

Use an empty stationary or similar box, the kind with a transparent cellophane or plastic cover. Fill the box with a soft bedding of cotton. Lay the insects onto the cotton. Bury some moth crystals in the corners of the box. Cover with the transparent lid.

Alcohol.

When bringing insects in to the university for identification, preserve them first. This prevents their becoming damaged or desiccated in transport.

Boil and then place an insect to be preserved in a small vial or bottle and cover with 70% alcohol. Use denatured ethyl alcohol, or ditto fluid (which is almost pure methyl alcohol), or drug-store rubbing alcohol

(which is usually isopropyl alcohol). Alcohol bleaches the specimens and makes them brittle but is a useful preservative for plump specimens such as caterpillars or grubs.

INSECTS ARE INTERESTING

Look for insects or words referring to insects hidden in this jumble of letters. The words go backwards or forwards, up or down, or diagonally. After all the words are searched out, 21 letters will be left unused. These 21 letters, copied in sequence, say something about insects. (Answers are on page 94).

H C A O R K C O C O O N I T

G E A I N M S G N Y M P H E

E R C R O T A N S L R A B R

L C E L P P A I I F O G U B

S I T N H E N W E B W O R M

I K C I T T N A U T Y E G O

L A D Y B E E T L E M L E S

A T A W E L T E E B R I T Q

S Y M R A E N R Y R A V I U

Y D S E R S A B S E B E M I

R I E F T I P U G N G E R T

H D L I O N O G A R D W E O

C Y E L L O W J A C K E T .

2. FOOD, WATER, CARE

SOLID FOODS FOR CHEWING INSECTS

50. DOG BISCUIT.

Pet foods usually contain a balance of proteins, fats, carbohydrates, and vitamins; and provide a good balanced diet to insects and other animals as well as to dogs and cats. In fact, if you have no other food than dog biscuit to give your chewing or licking insects, they may be well fed.

Crush dog biscuit into small pieces or into a fine meal with a rolling pin or the side of a glass jar. Serve very small portions, either as a dry powder or slightly moistened to make a paste. See Methods 70 and 71, two pages below.

51. FRESH FRUIT.

Many insects enjoy biting or sucking on a small slice of apple as a special treat. Renew the slice every few days to prevent molding and contamination. Also try other fresh fruits, prunes, raisins, or small slices of raw potato. See Method 72.

52. VEGETABLES.

Insects which damage truck gardens enjoy a piece of lettuce, green string bean, cabbage leaf, spinach, or other fresh green vegetable placed on a plastic lid on the bottom of the cage. Exchange for a fresh piece every two or three days.

53. GREENS.

Gather some small branches of your insect's favorite garden flowers or weeds. Wash the leaves to remove possible parasite eggs. Put the stems in a vase of water and place the bouquet in the insect cage. Change the bouquet when the leaves are well eaten or when they begin to wilt or dry up.

54. LIVE FOOD.

Some insects will eat only living, moving food. In some laboratories, flies, aphids, and other small insects are purposely raised to serve as food for preying mantids, chameleons, and other predators. See Mealworm raising methods in Section 3.

55. ENRICHED CARBOHYDRATE MEAL.

Mix:

-2 parts rolled oats or uncooked cream of wheat or corn meal

-1 part sugar
-pinch of salt

Serve as a dry mixture or moisten to make a paste. Renew every two or three days. See Methods 70 and 71.

56. HIGH PROTEIN DIET - DRY.

Mix:
-1 part dry yeast powder
-2 parts skim milk powder
-1 part cream of wheat or other uncooked cereal meal
-pinch of salt

Keep in refrigerator as a dry mixture. Serve in dry powder form or add moisture to make a paste. When using as a paste, keep in mind that moisture begins action in the yeast. The dry mixture may be kept in the refrigerator for some time but moisten only one day's food supply at a time and renew the cage serving daily. Serve by Method 70.

57. SWEET PASTE.

Mix:
-2 parts wheat bran or uncooked oats, cream of wheat or corn meal
-1 part molasses or syrup
-a few drops of water to make a paste

Serve in small portions by Methods 70 and 71 and renew every two or three days.

58. TETRAMIN.

Tetramin fish food is nourishing not only for fish but also for water-living insects. Tetramin has the advantage of not quickly fouling the water in case of over-feeding.

LIQUID FOODS FOR SUCKING INSECTS

60. SUGAR SOLUTION.

Sugar, in this context, means granulated sugar, brown sugar, raw sugar, honey, molasses, or any of the brands of syrup.

Mix 1 part sugar (any kind) with 2 parts water. More dilute sugar solutions are preferable for many insects. For butterflies use 1 part sugar with 20 parts water.

Serve in small portions and renew every few days by Methods 73, 74, 75, 76, 77.

61. HIGH PROTEIN DIET - LIQUID.

Mix:
-1 part egg white
-1 part corn or vegetable oil
-1 part syrup
-2 parts water

Stir.
Store in refrigerator.
Shake before using.
Feed by Methods 75 or 77.

WATER

All living things, including insects, require water.

A few insects and other animals are able to extract all the water they need from the succulent greens they eat. Unless you are sure your insect is of this type, water should be provided in the cage. However it cannot be an open dish of water. Most insects, given a dish of water, promptly fall into it and drown.

Water can be provided in insect cages by Methods 73 to 77.

METHODS OF SERVING FOODS AND WATER TO INSECTS

FOR SOLID FOODS

70. SODA BOTTLE CAPS.

The cap of a pop bottle is a good size for serving an insect meal. Dry dog biscuit powder, other dry powder foods, and paste foods can be placed in a bottle cap. Renew the supply every two or three days, even if it has not yet been completely eaten up, to prevent spoiling and contamination.

71. PASTE SQUARES.

Paste foods can be made by slightly moistening dry powdery meals. The paste can be spread while moist onto pieces of paper and allowed to dry. When dry, cut into 1-inch squares and keep in a jar in the refrigerator. Serve 1 square at a time.

72. PLASTIC PLATFORMS.

Use the plastic cover of a jar as a dish on which to place vegetable leaves, slices of fruit, or any food which might get moisture onto the cage floor and encourage mold.

FOR LIQUID FOODS AND WATER

73. SPONGE IN DISH.

Use a small lid with a relatively deep rim. Cut a sponge to completely fill the space in the lid. Fill the lid with water or sugar solution up to the top of the sponge. The insects can lick from the sponge without drowning in the container. Renew every two or three days.

74. UPSIDE-DOWN DISH.

Fill a small bottle to the brim with water or sugar solution. On top, lay a circle of absorbent paper towel about 1 inch larger than the top of the bottle. On top of that set a plastic lid large enough to cover the paper towel.

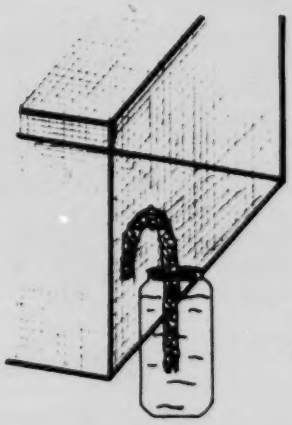
Quickly turn the entire apparatus upside down and place on the floor of the insect cage. The liquid will seep out and keep the paper towel moist.

75. WICK.

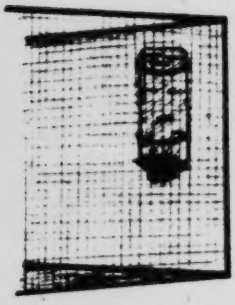
Place a bottle of water or sugar solution next to an insect cage.

Use a dental roll as a wick; or make a wick by tightly rolling up a rectangle of cotton in cheesecloth.

Place one end of the wick in the liquid. Insert the other end of the roll through a hole in the side of the cage. Let it hang into the cage but not touch the floor. The liquid will seep through the wick and supply moisture to the insects inside the cage.



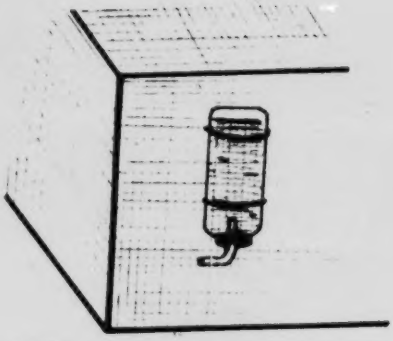
76. HANGING BOTTLE.



Fill a small vial or bottle to the brim with water or liquid food. Over the top stretch a piece of mesh nylon and hold it down firmly with a tight rubber band.

Quickly invert the bottle. The liquid will not run out. Hang it upside down inside the cage. Insects can lick from the surface of the nylon mesh.

77. HANGING TUBE.



Fill a small bottle with water or liquid food. Drill a small hole in the bottle cap and insert a piece of tubing so that it is leak proof.

Fasten the bottle, upside down, to the outside of the cage. Direct the hanging tube to the inside of the cage. The liquid will come down to the tip of the tube where the insects can lap it up.

The liquid will not run out of the bottle so long as the cap is leak proof, and so long as the tube inside the bottle is immersed in liquid.

CARE OF INSECTS IN CAGES

80. SPACE.

In general, insect cages can be small. The size of the cage should be in proportion to the size of the insect, to its activity, and to the number of insects in the one cage. Flying requires more room than crawling. Crawling requires more floor space than height.

81. FLOORING AND HIDING PLACES.

The floor of the cage needs to provide some traction for crawling insects. A paper towel or a light layer of sand provides for this and at the same time permits ease in changing and cleaning.

Some insects are thigmotactic. This means they show a preference for having at least one other part of their body, besides their feet, in

contact with another surface. If a loose paper towel is placed on the bottom of the cage, they crawl under it so that they can make contact with both the floor of the cage under their feet and the paper on their backs. Putting a transparent plastic container in the cage can provide a touching surface and still allow observation of the insect.

82. LIGHT.

Except for some of the strong daytime flyers, most insects prefer darkness. Keep insect cages out of the direct sun and preferably not in the brightest parts of the classroom.

83. TEMPERATURE.

Most insects thrive at about the same temperatures that we do, or somewhat warmer. Unlike us, insects cannot regulate their own body temperatures. Their bodies are about the same temperature as their environment. In a warmer environment they are more active. In cool weather, activity and growth slow down.

Insect activity can be greatly slowed down by placing the cage in the refrigerator, (not the freezing section) for about half an hour or longer. Upon taking it out you have about 5 to 10 minutes to observe the insects in slow motion before they warm up enough to resume their normal running or flying speed.

84. HUMIDITY.

Humidity has to do with the amount of water moisture in the air.

Flies and some other delicate flyers are killed by high humidities. They need to be kept in screen cages with good ventilation. Silverfish and some other thin-skinned insects prefer a high-humidity and moist atmosphere. For them, a glass jar with little or no air circulation is agreeable.

85. CLEANLINESS.

Students should be responsible for keeping their insect cage floors changed, and food and water supplies frequently renewed. Clean and aesthetically pleasing cages make for a more pleasant classroom atmosphere. Supplies of paper, food, and equipment can be kept out of sight in a drawer or closet.

86. IDENTIFICATION.

Each insect cage should bear a sign giving:

1. The name of the insect.

2. The name(s) of the students caring for the cage.

SECTION 3. INSECT INVESTIGATIONS

Section 3 is a catalog of experiments with insects which can be done with a class or with small groups of students. The insects are not listed in any kind of rational order. This section gives simply a collection of potential experiments which can be selected, or not selected, for use in whole or part, and in any sequence.

For each topic, some Background is given for the teacher's information. This is best shared with the student only in response to their questions, if it is taught at all.

Vocabulary is listed to be used as desired according to student ability and interest.

Capture and Laboratory Maintenance for each insect is referred to by number, corresponding to the numbered items in Section 2 of this book.

Investigations and Problems are labelled for Bands 1, 2, 3, as a hint of level of difficulty.

Suggestions on how to get investigations started; teaching strategies for the management of the work; instructions about controls, variables, and replications, criteria for data logging and for oral and written reporting are all in the PROGRAM MANUAL. The MANUAL needs to be consulted on these points before embarking on the specific insect investigations given in this Section.

1. STINKBUGS

Background

Stinkbugs make an ideal classroom experimental insect. They are large enough to view easily yet they occupy little space. They are clean, hardy, easy to care for, interesting to watch, and show marked changes in color at each molt. A raft of 50 to 150 eggs will hatch in about a week. The young nymphs reach maturity in about 5 weeks. The nymphs go through 5 instars or moltings, each one colorful and strikingly different from the one previous. From the 5th molt emerges the jade-green, shield-shaped, winged adult.

Southern Green Stinkbug (Nezara viridula) was first seen in Hawaii in 1961. It spread rapidly and soon was causing sufficient damage to local crops to bring action against it by the Department of Agriculture. Two parasites were brought in to combat it; a wasp which parasitizes stinkbug eggs; and a Tachinid Fly from the West Indies which turned out to be the

effective control. The Tachinid Fly lays eggs which look like white, oval lozenges on the outside of the adult stinkbug body. After hatching, the larvae bore into the stinkbug and eat it out. This parasite has so greatly reduced the stinkbug population in Hawaii that stinkbugs are now becoming hard to find.

Stinkbugs eat almost any green plant or fruit and have voracious appetites which is what makes them a curse to vegetable growers, particularly in the Southern United States. The bugs pierce the skin of the stem, leaf, or fruit, and suck out the plant juices. Stinkbugs emit a strong odor when annoyed but the stinkbugs at the Laboratory School have been so well behaved the students have yet to smell them.

To get a colony started in the laboratory, it is easiest to begin with the capture of several adults who then lay eggs on the undersides of green leaves provided for that purpose. From the colonies which result, investigations can be gotten underway.

If adult bugs are captured which are carrying white oval eggs in the folds of their bodies, these can be isolated in separate cages and watched for the emergence of the Tachinid Fly and the effect on the stinkbug host.

Vocabulary (To be used, used in part, or not used, as seems feasible).

Nezara viridula belongs to the Order of Insects called Bugs, or True Bugs, or Hemiptera.
Hemiptera or Bugs have leathery front wings (Hemelytra), lacy back wings held flat over top of body, and pointed sucking-piercing mouth parts.
The Molt or Molting is the shedding of the skin from time to time.
An Instar is a stage of the insect between successive molts. The first instar is the stage between hatching and the first molt.

Laboratory Maintenance

Collect: Method 10 or 24

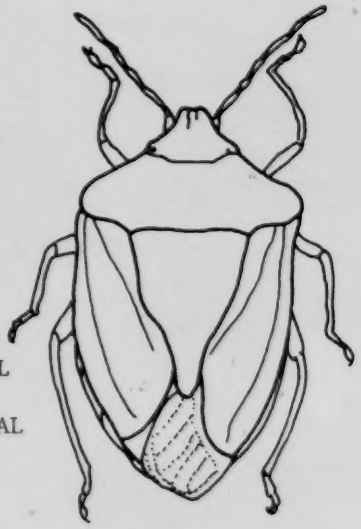
Cage: Type 30, 31, 32, 33, 34 or 36

Food: Types 51, 52, 53, 60, 61

Care: Methods 72, 73, 76, 80, 82, 83, 84, 85, 86

Experimental Procedures: See PROGRAM MANUAL

Oral and Written Reports: See PROGRAM MANUAL



Investigations with Stinkbugs

1. LIFE HISTORY Bands 1, 2, 3 (pursued at varying depths)

Problems:

What are the different stages in the life cycle of the Southern Green Stinkbug?

How long does it take to go from egg, through each stage of growth, to adult?

How does each stage look?

Suggested data table:

Table ___ Developmental Stages in Southern Green Stinkbug

Date	Event	Sketch	Remarks

2. STINKBUG ODOR Band 1 (Also 2 and 3 if desired)

Problems:

What kind of odor is given off by stinkbugs?

When is the odor given off?

Annoy a stinkbug until it "poofs" out an odor. What means was most successful in getting the bug to "poof"?

What kind of odor does it give off?

How long does the odor last?

From how far away can the odor be smelled?

3. FOOD Band 2 (perhaps Band 1 also)

Problems:

What different kinds of vegetation will stinkbugs eat?

Given a variety of foods, which do stinkbugs prefer?

4. PARASITE Band 3

Isolate an adult stinkbug which is carrying Tachinid Fly eggs on its body.

Problems:

How soon does the parasite produce an effect on the stinkbug?

What happens to the stinkbug?

What happens to the parasite egg?

What does the Tachinid Fly look like when it finally comes out?

Suggested data table:

Table ___ Observations on Parasitized Stinkbug and Its Parasite

Date	Effects on Stinkbug	Observations of Parasite	Remarks

2. CRICKETS

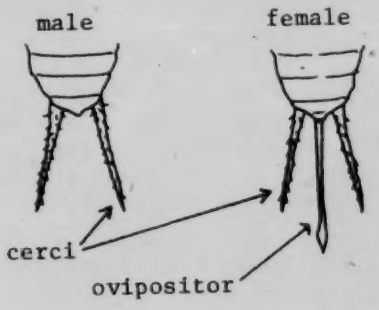
"To have a cricket on the hearth is the luckiest thing in all the world."

--Charles Dickens

Background

Crickets (Family Gryllidae) make clean and interesting pets, easy to raise and keep in a classroom. Many crickets may be kept in one cage. Their life span is about 3 months or longer.

Kept dark, warm, fed, and many together, crickets will entertain for hours with their singing. Only male crickets sing. The sexes may be distinguished by the "tail" pieces. The male has two cerci extending backwards from the rear of the abdomen. The female has two cerci plus a long center "tail," the ovipositor used for digging holes in the ground and laying eggs.



Vocabulary (to be used as feasible)

Crickets belong to the Order of Insects called Orthoptera.
Grasshoppers, Katydids, Cockroaches, and Praying Mantises are also Orthoptera.
Orthoptera generally have long, narrow, tough front wings called the Tegmina. The singular is Tegmen.
The rear wings are usually broad, lacy, and folded like a fan when at rest.
Most Orthoptera have chewing mouth parts, long antennae, and well developed Cerci. The singular is Cercus.
The baby cricket is called a nymph. It resembles its parent except for size and lack of wings.

Laboratory Maintenance

Get a colony of crickets started by trapping crickets from the neighborhood in places where crickets have been heard singing.

Capture: Methods 11, 20, 25

Cage: Types 31, 32, 33, 34, 36

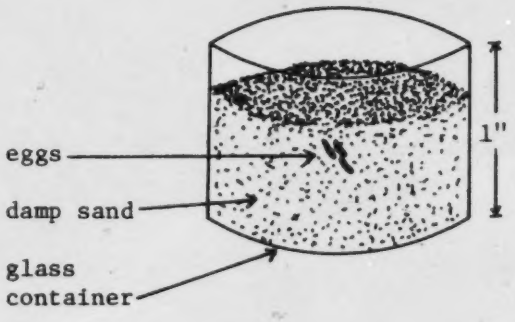
Food: Types 50, 51, 52, 53, 55, 56, 57

Care: Methods 70, 71, 72, 73, 80, 81 (with dry sand), 82 (dark), 83 (very warm), 84, 85 and 86.

Experimental Procedures: See PROGRAM MANUAL

Oral and Written Reports: See PROGRAM MANUAL

For reproduction, add into the cage a glass container of moist (not wet) sand about 1 inch deep. Small, banana-shaped eggs laid individually in the damp sand will be visible through the glass sides of the container.



Every two weeks, or oftener, remove the egg chamber with its eggs and place it in a "nursery." Give the female crickets a new container of damp sand in which to lay more eggs.

The nursery is a separate cricket cage into which is put the glass dish of damp sand containing eggs. The tiny nymphs hatch in about 3 weeks.

Feed the nymphs in the nursery by sprinkling powdered dog biscuit over the damp nursery sand. Lay a small slice of apple on the sand. Change the slice every 2 or 3 days. Lettuce leaves or other green vegetables placed directly on the damp sand make good nursery foods. Keep the nursery sand clean and damp but not wet.

When the nymphs are big enough to hop about and fend for themselves, they can be put with the adult crickets or into other cages of their own.

Investigations with Crickets

1. LIFE HISTORY Bands 1, 2, 3 (with varying degrees of refinement)

   See directions above for egg laying container and nursery.

Problems:

How do baby crickets look?

What are cricket eggs like?

Problems (cont'd):

How and where are the eggs laid?

How soon do the eggs hatch?

How do the nymphs (baby crickets) behave?

What do they eat?

Do the nymphs sing?

Do the nymphs have wings?

How fast do they grow?

How old are they when they begin to hop about?

Sample data table:

Table ___ Life Cycle of a Cricket

Date	Event	Sketch	Behavior and Other Remarks

2. TEMPERATURE Band 3

Build a l-o-n-g cage. Throughout the cage have the same darkness, air, food, water.

Keep one end of the cage very warm. Use a heating pad or any other warming device; but be careful not to build a fire trap. A covered light bulb is a fire trap.

Keep the other end of the cage cool. Intermediate temperatures may be found between the warm and the cool ends of the long cage.

Problem:

At which temperature spot in the cage do most of the crickets spend most of their time?

Sample data table: (This is only one style. The table may be set up in other ways.)

Table ___ Temperature Preferences of Crickets

Number of crickets found at different temperature sites along the cage							
	65°F	70°F	75°F	80°F	85°F	90°F	95°F
Day 1							
Day 2							
Day 3							
Day 4							
etc.							

3. CRICKET SONG Band 3 (or a reduced version for younger children)

Problem:

When and under what environmental conditions do crickets sing most?

Test for times of day, temperature, darkness, background noises, presence of females, number of crickets in cage.

Sample data table: (An example of multiple variables in one table)

Table ___ Times and Conditions of Cricket Song						
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Amount of singing taking place (0, 1, 2 & 3)*						
Time of day						
Lightness or Darkness						
Temperature						
Other noises going on in area						
Number of males in cage						
Number of females in cage						
Size of cage in cubic inches						

* 0 = silent (no singing)
1 or 2 = some singing
3 = loud, steady singing

For other experiments with insect song, see the next topic.

4. KINDS OF CRICKETS Bands 1, 2, 3

Problem:

How many different kinds of crickets can you find in your neighborhood? Crickets are distinguished by their body shapes, sizes, and colors. For identification, consult an entomology book from the library.

3. INSECT SONGS

Background

Many insects "sing." When insects produce their various songs they are said to stridulate, chirp, whirr, tick, buzz, beat, pipe, or trill.

Insect sounds are usually produced by rubbing one body part against another. The parts rubbed together are fitted with rough bumpy surfaces. The rough area on one body part is called file, or strigil, or tubercles, or pegs, or rasp, or ridges, or granular plate. The opposing rough surface is a row of "teeth" called the scraper or the comb.

The file may be on one wing edge and the scraper on the other wing edge, as in crickets. The file may be on the abdomen and the scraper on the inner edge of the hind leg as in many grasshoppers. The file may be on a wing and the scraper on one leg as in the short-horned grasshopper. Any two body parts which can be rubbed together may be the site of the scraper and the file.

Some insect sounds are produced by other methods. Flies, mosquitoes, and some other flying insects make their buzzing sound because of the rapid beating of their wings in the air. Queen bees have a high pitched piping call which seems to come from their throats.

Most insects sing at night but some insect songs can be heard in the day. The "normal song" of insects may occur at any time. Defensive or warning calls are sounded when danger is near. Mating songs may be seasonal to call females or to sing to females who are nearby. Male insects generally stridulate louder and longer than females. In crickets only the males stridulate.

Because insect songs are produced predominently at night, many of the insect song investigations may have to be pursued at home with the discussion and report work done in school.

Insect Song Investigations

1. THE STRIDULATING DEVICE Bands 2 and 3

   Capture some crickets, grasshoppers, and other insects which make noises. Inspect them carefully with a hand lens for the location of scraper and file. Look especially on wing edges, inner leg surface, and sides of abdomen.

Problem:

In singing insects, which parts of the body are rubbed together to produce the song?

Make a list giving the name of the insect and what body parts it uses to stridulate.

2. IMITATION INSECT SINGING Bands 1, 2, 3

Problems:

Can you stridulate? (either yourself or with a tool you can use)

Can you invent an instrument which imitates the sound made by insects when rubbing the scraper over the file?

Can you imitate the sound well enough to fool an insect?

3. MALE BEHAVIOR Band 3

This experiment may be tried with any singing insect, but crickets may be the easiest to handle.

Problems:

How is the singing of male insects affected by the presence of females?

Will the male sing when no female is around? Does he sing in her absence to call her?

Does a male begin to sing as soon as a female is put into his cage? If not, when does he start?

Does the male SEE the female? Separate them by a glass plate through which they can see, but not feel or smell or hear.

Does the male SMELL the female? Separate them by a barrier through which odors can pass but which they cannot see through.

4. FEMALE BEHAVIOR Band 3

Problems:

How do females react to male singing?

Do females behave differently toward males who are singing than to males who are not singing?

Will the female respond to a tape recording of the male song? To record the male song, put him into a tiny cage, about a one-inch cube, which has the tape recorder microphone for one wall. Play the recording to the female.

5. THE MUSICAL SCORE Band 3

Problems:

What kinds of sounds or musical notes make up an insect song?

Record an insect song at a fast speed on a tape recorder. Play it back at slow speed. The reduced speed lowers the tone, but slows down the repeated notes of the song so that they can be heard separately.

How may small "chirps" make up each section of the song?

Are they all the same pitch or are they a combination of higher and lower tones?

6. ORCHESTRATION OF INSECT SONGS Bands 1, 2, 3

Listen to the singing of insects at night out-of-doors.

Problems:

Does first one insect sing and then another? Do they sing all together?

Can you distinguish different songs?

At what times of day or night do they sing? When do they stop?

4. MONARCH BUTTERFLIES

Background

Monarch Butterflies migrated to Hawaii across the Pacific so long ago we do not have a date to mark their arrival. In Hawaii they found a plant of the milkweed family which is their nourishment: the crownflower.

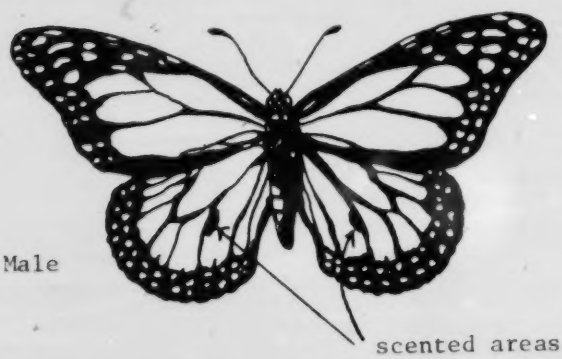
Witnessing the emergence of a Monarch Butterfly is, for younger children, an experience filled with aesthetic joy and wide-eyed wonder. Older children experience the same excitement and can add many learning advantages. Monarchs offer observations of a complete metamorphosis. Feeding habits of both caterpillars and adults make interesting projects. Monarchs can be mated in captivity. The Monarch parasite provides a study of an ecological relationship and biological control.

Monarch Butterflies, Danaus plexippus, are found throughout the world except in the Arctic regions. They are hardy, strong fliers with long migration paths and are sometimes found wintering in huge concentrations in the Southwestern United States.

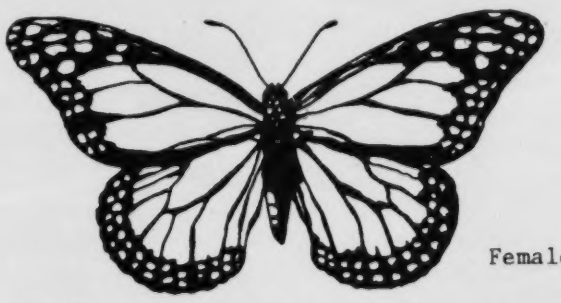
The "best" Monarch season in Hawaii is January, February, and March. The sparsest times are September, October, and November.

Monarch eggs are laid one at a time on or under crownflower leaves. The eggs hatch into black, white, and yellow striped caterpillars which grow to 2 or 3 inches in length. Then they change to pupae and hang from a leaf or stem as pale green, gold-spangled chrysalides until time to emerge as adult butterflies.

Male and female Monarchs may be distinguished by the black dot in the rear wings of the male. The black spots are "spongy" areas saturated with an attractant odor. The male manufactures the scent in his abdomen and transfers it to the spongy spot on the rear wings. The female is attracted to the odor. Females are sometimes seen flying closely behind males as they flit about in tandem.



Male



Female

Monarch Butterflies in Hawaii are parasitized by the Tachinid Fly, Lespesia archippivora. The fly eggs are laid on crownflower leaves. As the Monarch caterpillars feed, they swallow the parasitic eggs which then hatch and begin to feed inside the caterpillar. The caterpillar continues to grow for awhile, and it can pupate; but within a few days after pupation, the fly larva has destroyed the pupa inside the green case, changing the color to a dull black.

The small Tachinid Fly maggot eats its way out of the dead butterfly pupa and drops to the ground (or cage floor) where it pupates in a small structure resembling a rice grain.

When caterpillars are raised in captivity, crownflower leaves fed to them should be well rinsed or brushed first to remove parasite eggs. In making the butterfly tree described in Activity 2, leave the chrysalides hanging in their cages for about 6 days after they are formed before transferring them to the "tree." Monarch pupae which were parasitized and are dead can then be removed. The parasitic pupae can be collected from the floor of the cage for a study of the parasite.

Vocabulary (To be used insofar as the terms are desirable for a given grade level.)

Moths and butterflies belong to the Order of Insects called Lepidoptera.
Lepidoptera are distinguished by colorful (usually) showy wings covered by powdery scales which come off like dust when the wings are handled.
The larva (plural larvae) is a caterpillar.
The larvae have chewing mouth parts for eating leaves.
When the caterpillar goes inside its case it is no longer a larva. It is a pupa. The plural is pupae. The covering is the pupal case. The act of going inside the case is pupation. The insect is now in the pupal stage. It has pupated.
When a moth pupates it spins itself into a cocoon.
When a butterfly pupates, it wraps itself in a pupal case and is called a chrysalis. The plural is chrysalides (four syllables).
The Monarch chrysalis is not asleep. It is working very hard in there growing wings and changing to a butterfly.
The adult is called an imago. Plural, imagines or imagos.
The adults have sucking mouth parts for drawing up nectar from flowers. The part of the mouth which does the sucking is a long tube or proboscis coiled like a spring under the head. The proboscis can be uncoiled to reach into the nectar cup of a flower.
The series of changes from egg to larva to pupa to adult, typical of all moths and butterflies, is called metamorphosis.

Laboratory Maintenance

For the egg, larva, and pupa stages:

Collect: Hand pick

Cage: Style 30, 31, 32, 34, 36. The larvae make a fulsome mess and the paper on the bottom of the cage needs daily changing.

Food: Crownflower leaves sprinkled with water droplets. Keep fresh leaves held up on their stems or on wires, not lying on the cage floor where they mat together and become fouled.

Care: Methods 53, 72, 80, 83, 85, 86.

For the adult butterflies:

Collect: Methods 10, 12, 26.

Cage: Types 31, 32, 36. Butterflies need broad, wide screen cages for horizontal flight but they need little space for flying up and down. The cages can be shallow, e.g. two window screens placed horizontally and separated by cardboard or wooden sides.

Food: Type 60 very dilute; no more than 1 teaspoon sugar to 1 cup water; or even more dilute.

Care: Methods 70, (for sugar solution) 76, 77, 80, 82 (bright light or sun) 83, 84 (dry), 85, 86.

Investigation Methods: See PROGRAM MANUAL.

Science Reports: See PROGRAM MANUAL.

Monarch Butterfly Investigations

1. EMERGENCE OF CHRYSALIS TO ADULT Band 1 (Primary children)

Problems:

Watch the emergence of a butterfly from its pupal case.

Watch the gradual unfolding of the new wings.

Suggestions:

Collect pale-green, gold-spangled chrysalides from crownflower bushes.

Hang the chrysalides in a bright, sunny spot in a convenient place for classroom viewing. They need not be caged.

Some day, at least one of the butterflies will come out, hopefully during class time. When it does, all other lessons come to a halt while several dozen bright eyes drink in the miracle.

2. THE BUTTERFLY TREE Band 1

Problems:

Watch the changing of a larva into a chrysalis.

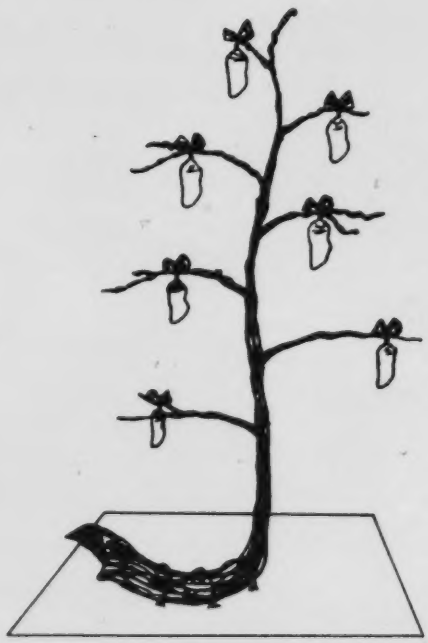
Make a "butterly tree" and watch the butterflies emerge.

Suggestions:

Collect large-size larvae from crown flower bushes. Large larvae will soon pupate and thereby obviate the task of feeding and cage cleaning over a long period.

Use nylon mesh or net pulled taut over the top of a jar in which the larvae are placed.

At pupation time, the larvae will climb to the underside of the tight net and hang there. With luck, the work of shedding the caterpillar skin and changing into a green chrysalis will occur during school hours.



When all the pupae have become encased, empty and clean the cage but keep the chrysalides hanging from the roof of the cage for about 6 more days. By then, parasitized pupae will turn black and can be discarded.

Cut strips in the mesh to include in each strip the spot from which a pupa case is hanging. Do not cut the "rope" by which the chrysalis hangs.

Obtain a dried stalk of a coconut or other palm flower or use any dried branch; and nail it to a base board.

Tie the mesh strips to the dried branches. Place the branch with its burden of pupa cases, in a sunny location. Morning sun encourages emergence early in the day.

When the butterflies emerge, they will stay near the branches for a short while before flying away, making the stalk into a beautiful Butterfly Tree.

3. LIFE HISTORY Bands 2 or 3 (Middle or upper elementary)

This is an extensive investigation from which some questions may be selected for study; or the work may be divided among teams.

Problems:

What stages does a Monarch Butterfly go through during its life time?

Find out all you can about each stage from egg to adult.

a. EGGS

Where are the eggs of Monarch butterflies laid?

How do they look? What size are they? What color?

Monarch eggs are tiny pale spheres laid singly on or under crown-flower leaves. If none can be found, try capturing adult butterflies and provide them with crownflower leaves on which they might lay eggs.

b. LARVA

What is the color, shape, and sizes of Monarch larvae?

What kinds of stripes do they have?

Do small caterpillars and large caterpillars have the same number of stripes? Do they add more stripes as they grow?

Are the stripes the same number, colors, and sequence on every caterpillar or do they vary?

What kinds and how many feet, horns, and other features do the larvae have?

How do they use their feet in crawling? How fast do they crawl?

b. LARVA (cont'd)

How do the caterpillars respond to touch? to light? to heat? to nearby sounds or to loud sound? to odors of fresh leaves? to juices of crownflower leaves put on other leaves?

Are all parts of the body equally sensitive?

How long a time is it between the hatching of the egg until the caterpillar changes to a pupa?

c. PUPA

Describe the changing of the caterpillar into a chrysalis.

How long does the change process take?

Does the chrysalis respond to touch?

How long does the chrysalis remain in the pupal case?

d. IMAGO

Watch a butterfly emerge from the pupal case.

How long does it take to emerge? How do the wings unfold?

What does the discarded case look like?

Suggested Data Table:

Table ___ Life History of a Monarch Butterfly

Date	Stage	Size	Appearance	Behavior

4. CATERPILLAR GROWTH AND FEEDING Band 3 (Advanced elementary with quantitative work)

Problems:

a. How much per day does a caterpillar grow?

How much does it grow altogether from the time it is hatched until it changes into a pupa?

Calculations may be made either of the daily gain in weight or of daily growth in length.

b. How much does a Monarch caterpillar eat each day?

How much does it eat altogether from the time it hatches until it changes into a pupa?

The amount of food can be measured either by weight or by surface area.

By weight, weigh the crownflower leaves put into the cage. Then weigh the amount of leaf left uneaten. The difference represents the amount eaten by the caterpillar.

By surface area, cut the crownflower leaves into 1-centimeter squares. Mount the squares on strong wires and make them into a bouquet to place in the cage. Each square eaten means an intake of 1 cm^2 of leaf.

c. What is the gain in weight of a caterpillar compared with the amount of food eaten?

This is a very sophisticated experiment for elementary children. It requires careful daily measuring of food intake and caterpillar growth, both preferably by weights. Several caterpillars need measuring and averages taken. The results can lead to a discussion of the efficiency of metabolism. As a teacher reference, see any college ecology text on trophic levels.

d. What will Monarch larvae eat besides crownflower?

Given a mixture of many kinds of leaves including crownflower, what do they eat?

Given several kinds of leaves but no crownflower, what will they eat?

Will they eat other leaves if crownflower juice is put on them?

5. FEEDING ADULT BUTTERFLIES Band 2 or 3

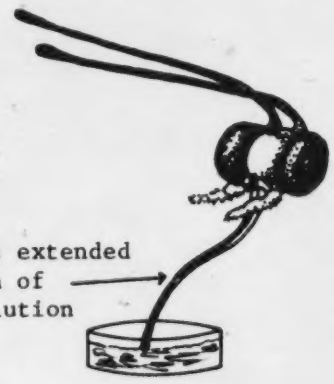
Problems:

Train an adult butterfly to drink a sugar solution from a small dish.

What concentrations of sugar solution do butterflies prefer?

Hold a butterfly gently by its wings without rubbing off the scales. Insert a small sharp object, such as a well sharpened pencil point, in the middle of the coiled proboscis. Pull outwards to unwind the coil and try to touch the tip of the proboscis into a sugar solution. Do this several times. If the butterfly likes the sugar solution it will soon uncoil its proboscis by itself and drink from the dish.

Insert small instrument here and pull coil out



Proboscis extended into dish of sugar solution

6. THE MATING OF MONARCHS Band 3

Problems:

Distinguish male from female butterflies (see Background notes).

Mate a male and female butterfly. (This could be used as the first step of the life cycle study.)

Suggestions:

Butterflies reach sexual maturity about 3 or 4 days after emergence as adults from the pupal case. Males and females placed in an ample cage may mate naturally.

To induce mating, hold two butterflies gently by the wings, one in each hand, and touch the tips of their abdomens together. As soon as the male clasps the female securely, the mating pair may be placed gently on a branch in the cage. They may remain in the mating position for several hours after which the female is ready to lay eggs on crownflower leaves. The flapping of her wings between each egg laid seems to assist in the deposition of the eggs.

7. MONARCH PARASITES Bands 2 or 3

Problems:

Raise a Tachinid Fly from the maggots collected from a parasitized Monarch chrysalis.

What does the maggot which came out of the Monarch chrysalis look like?

What does the maggot do after it falls out of the dead chrysalis?

How long does it take the fly pupa to emerge as an adult fly?

What is the size, color, shape of the emerged adult Tachinid Fly?

8. COLOR VARIATION Bands 1, 2, 3

Problems:

Can you find any white Monarch Butterflies?

How many can you find?

White Monarchs are exceedingly rare on the Mainland. In Hawaii they can be seen with a low degree of frequency.

A white Monarch is NOT a white citrus swallowtail. It is a Monarch in which the parts which are ordinarily orange are white. The black markings remain black. It is not an albino. It is a mutant which for some unknown reason is relatively more common in Hawaii than elsewhere.

Comments from Pilot Teachers

For small children, the emergence of Monarch butterflies and the spreading and drying of the wings is invariably a fascinating experience.

After one 5th grade class had observed the larvae of the Tachinid Fly emerge from the dead Monarch crysalis, the teacher asked for an investigation of how and when the Tachinid Fly larva got into the Monarch chrysalis to begin with. The students found through considerable work on their own that the egg of the Tachinid Fly is eaten by the Monarch caterpillar. Perhaps such students should skip 6th grade and go directly into high school science!

Answer to puzzle on page 9: the code is that each letter of the alphabet is displaced by one position. B stands for A, C stands for B, D stands for C, etc.

The insects are cockroaches, bees, crickets, silverfish, butterflies, moths, mosquitoes, lady-bird beetles, ants, caddisflies, flies, praying mantis.

Answers to puzzle on page 79: legs, antenna, instar, halteres, stinger, bristles, molts, wings, cocoon.

5. TINEID MOTHS

Background

Flattish, oval-shaped, cocoon-like structures can sometimes be found in the crevices of building walls. These samll "cases" belong to a Tineid Moth (Tineola utrella). Its near relatives are the clothes moths which tunnel into garments and often build silken or woolen cases for themselves in clothing or furs.

The larva is a slender brown "worm" about 1 or 2 cm (½ inch) long, which builds its house from tiny bits of rubbish, sand grains, and silken threads. The adult is a delicate moth with feathery wings.

Laboratory Maintenance

Collect: 13, 24

Cage: 30, 36

Food: 50, 55, 56, 57 pastes or bits of wet vegetable

Care: 71, 73, with moist cage floor. Also 80 to 86

Experimental Procedures: See PROGRAM MANUAL

Student Reports: See PROGRAM MANUAL

Investigations with Tineid Moths

1. HOME OWNERSHIP Bands 2, 3

Problems:

When a larva is forced out of its case, can it find its way back?

When several larvae are dislodged, can they find their own cases?

Suggestions:

With a blunt instrument, such as a thin nail, push gently through one end of a case, forcing the naked larva out the other end. Place the larva and the case on a damp (not wet) paper towel. See if the larva can find its way back to its case.

Try several larvae and cases simultaneously and see if they choose only their own cases.

2. HOUSING CONSTRUCTION Bands 2, 3

Problems:

If a larva is deprived of its house, how long does it take to build a new house from raw materials?

What materials will it use?

Does the new house look like the old one?

Suggestions:

Eject several larvae from their cases gently, as in #1 above, and discard the cases. Supply one or more of the following building materials.

- -fine sand
- -short, fine strands of cotton or wool
- -small bits of moss or damp leaf bits
- -sweepings of dust
- -bits of thread or string
- -small section of drinking straw
- -short piece of plastic tubing
- -anything else of your choice

3. THE ADULT Bands 2, 3

Problem:

What does the adult moth look like?

Suggestions:

Keep several larvae in a cage (see laboratory maintenance) until they emerge as adults.

Sketch their appearance.

How many 3-letter and 4-letter words can you make from the letters found in the word

B U T T E R F L I E S

6. OTHER MOTHS AND BUTTERFLIES

Background

The Lepidoptera are showy insects whose beautiful wings attract considerable admiration. Unfortunately their larval stages are often very destructive to vegetable crops, garden flowers, and tree foliage.

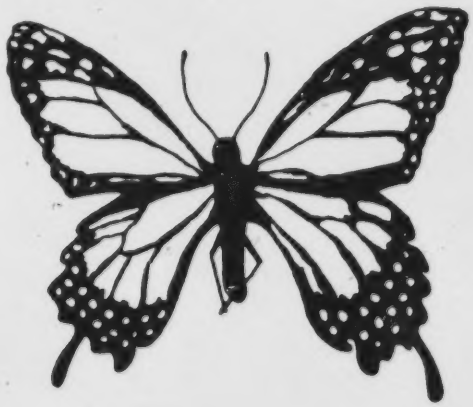
Only four moths or butterflies prominent in Hawaii are mentioned below. These, or any others seen flitting about the campus or home garden, may be chosen for study.

The Citrus Swallowtail

Swallowtail butterflies are larger than Monarchs and have tail-like prolongations on the hind wings. The Papilionidae (Swallowtail) Family includes many species which on the Mainland feed on garden vegetables, fruit trees, other hardwood leaves, papayas, and citrus.

So far in Hawaii we have only one citrus swallowtail which was accidentally introduced in recent years. The Citrus Swallowtail is white with prominent black veins and black tail.

It may be captured and cared for following the instructions for Monarch Butterflies except that the larvae should be fed citrus leaves instead of crownflower leaves.



The Oleander Hawkmoth

The Oleander Hawkmoth, Deilephila nerii, came accidentally to Hawaii in the early 1970's and is rapidly spreading mass destruction among the Oleander hedges.

This beautiful Hawkmoth, or Sphinx Moth, has widespread, long, narrow wings, brilliantly green with tints of pink. Its larva is a hornworm resembling the large green tomato worm which is also a hornworm. The name hornworm refers to the horn-like protuberance on the back end of the larva which the worm displays by rearing up when it is touched.

The Oleander hornworm, after feeding voraciously on Oleander leaves, drops to the ground to pupate. Young larvae are green with a white stripe on each side, fully grown larvae are blackish. The pupal case is black and does not have a "pitcher handle" such as is present on the tomato hornworm.

A curious thing about the Oleander Hawkmoth is that the larva thrives on Oleander, a plant which is deadly poisonous in all parts of its stems, leaves, bark, flowers, sap, and roots. Few insects and no other animal can survive even a small amount of Oleander toxin.

For laboratory rearing, follow the same general procedures given for Monarch Butterflies, but feed Oleander leaves instead of crownflower leaves.

The Black Witch

The Black Witch is a Noctuid Moth, Ascalapha odorata, and has a wing span of 5 to 7 inches. Noctuid moths feed on leguminous plants. A plague of dark, striped Black Witch caterpillars can strip a Monkey Pod tree bare in a few days.

Laboratory rearing procedures for Monarch in Topic 4 may be followed for studying Black Witches, but feed the larvae Monkey Pod leaves instead of crownflower leaves.

Black Witch Moth

The Banana Skipper

The Banana Skipper, Erinota thrax, is a brown butterfly. The green larvae are covered with white powder. For a while in Hawaii, Banana Skippers were a plague on banana patches but are now somewhat under control.

An interesting activity to do with a Banana Skipper is to look for the small green larva in a silken house inside a rolled-up banana leaf. Take it out, put it on a piece of glass, and view it from the underside. As a Banana Skipper crawls, it constantly wags its head from side to side, attaching a silken thread first on one side and then on the other. When it does this on the surface of a banana leaf, the silk thread pulls the leaf into a roll.

For laboratory maintenance of the Banana Skipper, follow the Monarch Butterfly instructions, but feed the larvae banana leaves instead of crownflower leaves.

INVESTIGATIONS WITH MOTHS AND BUTTERFLIES

1. LIFE HISTORY

Problems:

What are the different stages in the life cycle of the _____?
(name of moth or butterfly)

(Refer to Topic 4 on Monarchs for further ideas for investigations about eggs, larvae etc.)

2. DISTINCTIONS BETWEEN MOTHS AND BUTTERFLIES

Problem:

What things are alike, what things are different, between moths and butterflies?

This problem should be done after several moths and butterflies have been studied or observed so that the students have a base for comparison. Band 1 children may be able to find one or two items of likeness or difference. Band 3 students may find many, before the teacher steps in with some clarifications to whatever degree seems useful for the grade level.

The table below, but with Columns 2 and 3 left blank, can be given to the students as a working table. The information in italics is for the teacher, but it can be given to the students after they have exhausted all their own resources in filling in the columns.

Table ___ Likenesses and Differences between Moths and Butterflies

Item	*Moths*	*Butterflies*
Stages of life cycle	*egg-larva-pupa-adult*	*same*
Body size and appearance	*fat, hairy bodies*	*slender, smooth bodies*
Number of legs in adult	*6*	*same*
Number and type of antennae	*2-feathery plumes*	*2-strainght, smooth threads or with knobs at ends*
Number of wings in adult	*4*	*same*
Appearance or type of wings	*broad, with veins & bright-colored scales*	*same*
Position of wings when insect is at rest	*spread out flat over body* —•—	*folded erect over top of body* ‖
Time of day or night when most active	*dusk or night*	*daytime, in sun*
Type of mouth parts in larva	*chewing*	*same*
Type of mouth parts in adult	*sucking*	*same*
Type of pupa case	*silk cocoon*	*chrysalis*
What else have you noticed?		

7. MOSQUITOES

Background

Mosquitoes around the world are carriers of some dread and notorious diseases. In Hawaii they carry dengue fever, although no cases of dengue have been reported in Hawaii since the mid-1940's. Mosquitoes are also pests because of the discomfort of their bites.

Despite their grim reputations, mosquitoes are clean little insects which can safely be raised in the classroom for study. Their care and observation are simple, easy, and interesting. Because of their potential as disease carriers, their study is also important.

The first mosquitoes in Hawaii came from aboard a whaling vessel in 1832. Other species have been brought since then so that now we have six kinds of mosquitoes in Hawaii.

1. The most common mosquito in Hawaii is the night-biting Culex quinquefasciatus. Culex is the carrier of viral encephalitis, human filariasis (not in Hawaii), and dog heartworm. Culex has a uniformly brown body without stripes. The end of the abdomen is rounded. Its larva has a long, slender air tube by which it hangs from the surface film of water. When disturbed, the larvae swim downwards in C-shaped wriggles.

The eggs are laid in "rafts" in swamps and forest areas, preferably in large bodies of polluted waters such as agricultural ponds or sewage drainage areas.

Culex is a strong flyer. The female may travel as much as three miles from the breeding site to draw the blood she needs to make her eggs viable.

2. The day-biting mosquito, Aedes albopictus, now a nuisance biter, was the carrier of dengue fever on all islands of Hawaii. Aedes breeds in small puddles of water left standing in discarded cans or old tires about the yard or in vacant lots. It often uses water caught in the crevices of garden plants so that one of its nick-names is the tree-hole mosquito. It prefers small, quiet puddles of relatively fresh water.

The adult Aedes has a black body with a silver-white middle stripe and white banded legs. The abdomen is pointed, the larvae have a short air tube and when disturbed swim downwards from the surface in S-shaped wriggles.

3. A different Aedes, Aedes vexans nocturnus, is a vicious night-biter active at dusk and after dark. It lays its eggs in damp vegetation in abandoned areas on flood plains. Then after heavy rains when the area is flooded with water, the eggs hatch into larvae (wrigglers) which develop into pupae and eventually emerge as strong flying adults. The female may fly as far as 20 miles from her floodwater home to seek a blood meal. This

Aedes has a brown body with striped legs and a pointed tip to the abdomen. Lanai, Maui, and the Big Island of Hawaii do not have Aedes vexans nocturnus -- yet!

4. Molokai and Hawaii are the only two Islands so far which can boast of having the yellow-fever mosquito, Aedes aegypti. The yellow-fever virus does not automatically come with the mosquito. The yellow-fever disease has not yet been brought in to these Islands. When it is (for example, through an ill person) then Hawaii and Molokai have the carrier mosquito all ready and waiting to carry the disease.

Aedes aegypti is black decorated with a lyre-shaped design of silvery-white scales and banded legs. Pictures of Aedes aegypti are often shown in books which talk about yellow-fever. Aedes aegypti are day-time biters which live and breed in small clean puddles around domestic areas.

5. & 6. In the early 1950's, two "cannibal mosquitoes," Toxorhynchites spp., were introduced into Hawaii to prey on the four biting species we have. The two cannibal mosquitoes are much larger than the biting mosquitoes. They have bright-colored bodies and long, curved probosci. They are slow, delicate flyers with a short travel range. They live on plant juices and on other mosquitoes, and do not bite people. Although the "cannibals" were introduced about 20 years ago they have not yet succeeded in controlling the biters.

Life Cycle and Vocabulary

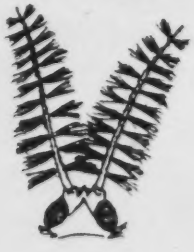
Mosquitoes, along with flies of many kinds, belong to the Order of Insects called Diptera, which means "two-winged."

Diptera have only one pair of wings. Behind the two wings are two knobs called halteres occupying the place of the two rear wings.

The mouth parts of the adults consist of a long proboscis for piercing and sucking.

In the mosquito, only the female pierces the skin of man and animals and sucks blood without which the eggs are not produced. Both males and females nourish themselves by sucking plant juices and nectar. Only the female makes the buzzing sound.

Adult males have feathery antennae. Adult females have antennae with only a few tufts of hair.



The eggs look like tiny black specks laid in, or near, water.

When the eggs are flooded with water, they hatch into larvae (singular larva) which, in the case of mosquitoes, are called wrigglers. Wrigglers feed on bits of decayed vegetation in the water. They

breathe through air tubes or spiracles by which they hang at the surface.

In 4 to 15 days, the wrigglers change to pupae called tumblers. Tumblers have large heads and small comma-shaped tails. The pupae of most insects rest quietly in cocoons or chrysalides. Mosquito tumblers are active and dive below the surface if the water is disturbed.

The adult mosquito emerges from the tumbler.

A mosquito, or any other animal which carries disease, is called a Vector. Mosquitoes are the vectors for filariasis, encephalitis, dengue fever, hemorrhogic fever, several bird diseases (transmitted when they bite birds), malaria, and yellow fever. These diseases are presently not a problem in Hawaii.

Laboratory Maintenance

Capture: 10, 13

Cage: 31, 32, 34, 35, 36. Use aspirator to transfer, or a medicine dropper for the wrigglers.

Food: 50, 51, 60, 61. The larvae are fed by adding a small pinch of dog biscuit or powdered yeast to the water but any scum on top of the water must be kept skimmed off to allow breathing.

Food #61 may be used to feed adult females in place of a blood meal. The egg white provides the needed protein for viable eggs.

Care: 73, 75, 80, 81, 82, 83, 84, 85, 86, plus open water for breeding. For observing the adults, float them in a white enamel dish with shallow water. The body colors and stripes will show against the white background.

Experimental Procedures: See PROGRAM MANUAL.

Student Reports: See PROGRAM MANUAL.

Mosquito Investigations

1. LIFE CYCLE Bands 1, 2, 3 varied according to ability

Perhaps the easiest stage to begin the life cycle study is the stage easiest to capture, i.e. the wrigglers collected from water holes. Look for wrigglers in natural water holes or vegetation, or make an artificial water hole in which a mosquito may lay eggs. Put out a can or glass with water in a shady spot. Use cistern water, rain, water, or Honolulu tap water which is pure artesian water without chemical purifiers added. In some country areas where water is "purified" using chemicals, faucet water cannot be used. Lean an ice cream stick in the water container to provide a surface for egg laying at the water's edge.

Problems:

Wrigglers — What does a mosquito wriggler look like? Draw a picture of one resting at the water surface.

How big are the wrigglers?

Describe their swimming motions.

How soon do they become tumblers?

Tumblers — How does a tumbler look? Draw a picture of one.

How do tumblers behave when disturbed?

What position do they remain in at rest?

How long do they remain tumblers?

Adults — Watch a mosquito emerge from a tumbler. A small piece of cork or paper floating in the water near the tumbler will help to give the new mosquito a foot hold.

How long does it take to emerge?

What gets left behind? Draw sketches.

Float an adult in shallow water against a white background so you can see its parts. Is it a male or female? What species is it? Sketch it, showing its banding and coloring.

Eggs — What do the eggs look like? Examine with a hand lens.

How long does it take them to hatch into wrigglers?

If you capture adult mosquitoes which have already had a protein meal such as blood or food #61, they may lay eggs on a damp paper towel hung over the side of a dish of water.

2. SENSITIVITY OF WRIGGLERS AND TUMBLERS TO MOVEMENT Band 1

Problems:

Watch mosquito wrigglers and tumblers dive downwards in the water when they are disturbed.

What kinds of disturbances make them dive? (shaking, movement nearby, shadows)

3. SENSITIVITY OF WRIGGLERS AND TUMBLERS TO MOVEMENT Bands 2-3

Problems:

What kinds of disturbances cause mosquito wrigglers and tumblers to dive?

How do they respond to shaking the container?

How much shadow movement produces a reaction?

Do they dive equally fast at different kinds of disturbances?

Do wrigglers and tumblers respond alike?

How long does it take them to resume resting at the surface?

If they are disturbed repeatedly, do they react slower, or faster?

4. DEPENDENCE OF WRIGGLERS AND TUMBLERS ON SURFACE AIR Bands 2-3

Problems:

How sensitive are wrigglers and tumblers to surface air supply?

Put oil on the surface of water containing mosquito larvae. Add only 1 drop of oil to one container, 2 drops to another container, and so on until the last container has the surface well covered with oil. As a control have one container with no oil.

In which of the containers do the wrigglers die? In which do the tumblers die? How long does it take for them to die? How do you know they are dead?

5. WAR ON NEIGHBORHOOD MOSQUITOES Bands 1, 2, 3

Several different kinds of "war" or "anti-mosquito contests" could be run with a class, depending on their age and interests, and also depending on the kind of neighborhood. One of the following contests may appeal to your class; or you may have a better idea especially suited to your particular neighborhood.

A. MRS. MOSQUITO GOES HOUSE HUNTING

Let each student pretend to be a female mosquito searching for a place in the school or home neighborhood in which to lay eggs. Which "mosquito" in the class is most successful in finding places? Have each "mosquito" keep a list of spots found. Don't forget the cups of ginger or bird-of-paradise blossoms, dripping water faucets, empty cans and bottles, bird baths, vases of flowers, plugged drain pipes.

Follow up the search with a destroy mission.

B. WANTED! A HOUSING SHORTAGE FOR MOSQUITOES

Working individually, or by teams, have the class scour the school neighborhood and their own home neighborhoods for potential mosquito breeding sites.

Each potential breeding spot found = 1 point.

Each potential breeding spot found and permanently destroyed so that it cannot hold water = 3 points.

Each spot found which actually had mosquitoes in it, and which was permanently destroyed = 5 points.

C. MY YARD'S BETTER THAN YOUR YARD

This is a "backwards" type of contest which might appeal to the perversity of human nature in some cases.

Assign each team in the class to a neighborhood public area, e.g. an empty lot, section of public park, section along a public street.

Allow a day or two "grace period" to allow each team to get its area cleaned out of mosquito breeding sites.

Thereafter, the teams hunt for potential mosquito breeding places on the property of other teams. If they find any, that team gets a mark against it. Set a time limit, e.g. two weeks, or even one weekend.

The winning team is the one against whose site no marks were reported by the rival teams.

Neighborhoods which would seem to need more attention than can be given by the students can be reported to the Vector Control Branch, Environmental Health Division, State Health Department. See your telephone directory for the agency office nearest you.

Central Office: Vector Control Branch
Dept of Health
2611 Kilihau Street
Honolulu, HI 96819

Phone: 847-4887

8. SILVERFISH

Background

Silverfish are exceedingly easy to care for and make a good observation project for small children.

Silverfish (Order Thysanura) are wingless, very fast moving insects which inhabit seldom disturbed corners of drawers, cracks in shelving, and other household nooks where they can keep themselves warm, dark and undisturbed. They come out at night to eat the glue and starch off book bindings, shelf-paper, draperies and curtains, stored clothing and linens, and the glue from labels, stamps, and wallpaper.

Laboratory Maintenance

Capture: with small net or aspirator

Cage: 30 - glass jar with moist sand bottom

Food: glue and starch

Care: Practically none. Glass jar with moist sand and glue/starch, kept in a dark place.

Experimental Procedures: See PROGRAM MANUAL

Student Reports: See PROGRAM MANUAL

Investigations With Silverfish

1. SILVERFISH FOOD PREFERENCES Bands 1, 2, 3

Problem:

What kinds of glues and starches do silverfish like best?

Place very small amounts of different kinds of glues and starches in the silverfish cage. Try such things as:

-postage stamp
-mailing label
-piece of book binding
-different kinds of household glues spread on bits of paper

-ironing starch
-flour paste
-corn starch
-potato starch
-rice flour paste
-other starches and pastes

After you find out what they like best, take that kind away and see what they like second best. What kind, if any, do they not like?

2. GROWTH OF SILVERFISH Bands 1, 2, 3

Problem:

How fast does a silverfish grow?

Glue a section of graph paper having very small squares to the bottom and/or side of the silverfish cage. When the silverfish is sitting on the graph paper estimate its size by the size of the squares. Try to begin with a small silverfish and measure its size every week against the size of the graph paper squares.

3. LIFE CYCLE OF SILVERFISH Bands 1, 2, 3

Problems:

How long does it take for one generation of silverfish?

How do the baby silverfish look at different stages?

Teacher's note:

Newly hatched silverfish look like the adults except for size and a few body proportions. Several generations can be gone through by beginning with a breeding pair (start with any few adults) and keeping them supplied with starches and glues in a moist-sand glass container.

9. COCKROACHES

Background

Cockroaches are important to learn about because they infest our homes, contaminate our food, dishes, and other articles, and carry diseases.

Cockroaches have flat, oval bodies. They hold their large, shiny, brown wings down flat over their bodies. They have hairy legs and long, graceful antennae.

Hawaii has 18 kinds of cockroaches. Most of them live out-of-doors and feed on plants and debris. Four kinds of cockroaches tend to infest our homes.

1. THE GERMAN COCKROACH

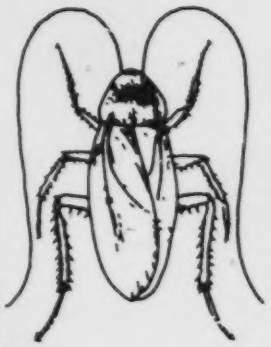
(Blattella germanica) About ½" long. Light brown with two dark stripes set lengthwise behind the head on the prothorax. Reproduction time may be as short as one month.

The female carries the egg case protruding from her abdomen until a few days before hatching. German cockroaches have become resistant to many insecticides, especially chlordane.

2. THE AMERICAN COCKROACH

(Periplaneta americana) Large. About 1½" long. Uniformly reddish-brown and shiny. Strong flyers.

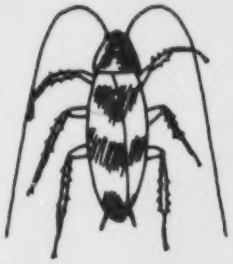
The egg purses are hidden in crevices and hatch in 2 or 3 months.



3. THE AUSTRALIAN COCKROACH

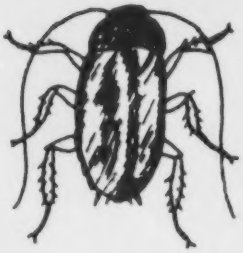
(Periplaneta australaisiae) About 1" long. Two yellow lines along the edges of the shoulders on the wings. Not as common as the other roaches.

4. THE BROWN-BANDED ROACH



(Supella supellectilium) About ½" long with light-tan, faint bands crosswise on the wings and abdomen. The wings of the female are shorter than her body. These roaches live in dry places such as desk drawers or radios.

5. THE CYPRESS AND OTHER OUTDOOR ROACHES



One of the common outdoor roaches is the Cypress roach or the Pacific Beetle roach. It is light brown and rounded and thrives in great numbers in outdoor rubbish piles. It eats the bark from plants and hedges.

Vocabulary (to be used according to need and desire)

Cockroaches belong to the Order of Insects called Orthoptera along with grasshoppers, crickets, and mantids.
The life cycle involves an egg case, or egg purse, or ootheca, from which hatch several dozens of nymphs. The nymphs resemble the parents except for lack of wings. After many moltings they become winged adults.
Cockroaches have chewing mouth parts.
Cockroach feces have a characteristic white spot at one end of the oval-shaped dropping. These droppings are the chief source of bacterial and viral contamination.
Cockroaches are thigmotactic. They prefer to feel their bodies in contact with several surfaces at the same time.

Laboratory Maintenance

Capture: 20

Cage: 30, 31, 32, 34, 36

Food: 50, 51, 52, 55, 56, 57, or any food plus glue and starch.

Water: very important. 73, 74, 75, 76

Care: 80, 81, 82 (dark), 83 (warm), 84, 85, 86

Experimental Procedures: See PROGRAM MANUAL

Student Reports: See PROGRAM MANUAL

Cockroach Investigations

1. LIFE CYCLE Bands 1, 2, 3

Problems:

How many baby cockroaches hatch from one egg purse?

How do baby cockroaches look?

How do they change as they grow?

How long does it take them to become grown up?

When do they get their wings?

What color changes can you notice when they molt?

Suggested data table:

Table ___ Cockroach Changes from Egg Case to Adult

Date	Size	Color	Shape	Remarks

2. THIGMOTAXIS IN COCKROACHES Bands 2, 3

Cockroaches prefer darkness. They also prefer to keep their bodies in touch with several surfaces at once.

Problem:

Which do cockroaches prefer more, darkness or a thigmotactic surface?

Suggested procedure:

Build a cage in which one end is kept dark but which has no hiding places. A large, round, dark tunnel, for example, would mean the cockroach could not touch any surfaces except with its feet. In the light end of the cage, put some transparent pieces of crumpled plastic or small transparent boxes so that the cockroaches have opportunities

to crawl into crevices and feel many surfaces against their bodies, but they have to be in the light to do so.

3. RESISTANCE TO INSECTICIDES Band 3 with care in handling the poisons.

German cockroaches in Hawaii have developed a resistance to Chlordane and possibly some other insecticides.

Problem:

How resistant are different species of cockroaches to different brands of insecticides?

Warning: Many insecticides are harmful to humans as well as to cockroaches. Read the labels on the insecticides.

Suggestions:

The problem, as it is stated, involves many variables. The first thing that has to be decided is which cockroaches will be tested using which insecticide. Remember about controls and replications. See the PROGRAM MANUAL. Decide on how to measure insecticide effectiveness or resistance. When 50% of a population is knocked out by a given poison it is said to be LD_{50}, meaning lethal dose for 50% of the population. This is a common standard.

4. FAVORITE HAUNTS OF COCKROACHES Bands 1, 2, 3

Problems:

What places inside houses do cockroaches like best?

What are the characteristics of their favorite hiding places?

Suggestions:

In the middle of the night, turn on a light in different rooms of the house. If any cockroaches are out, see where they run to, to hide.

With an aerosol insecticide spray, squirt into places where cockroaches may be hiding and see what you can chase out. What kinds of places do they seem to like best?

5. ATTRACTING AND REPELLING COCKROACHES Bands 1, 2, 3

Challenge #1

If you wanted to have a cockroach-proof room, what would you do or not do; what would you have in it or not have in it?

Give a reason for each of your ideas.

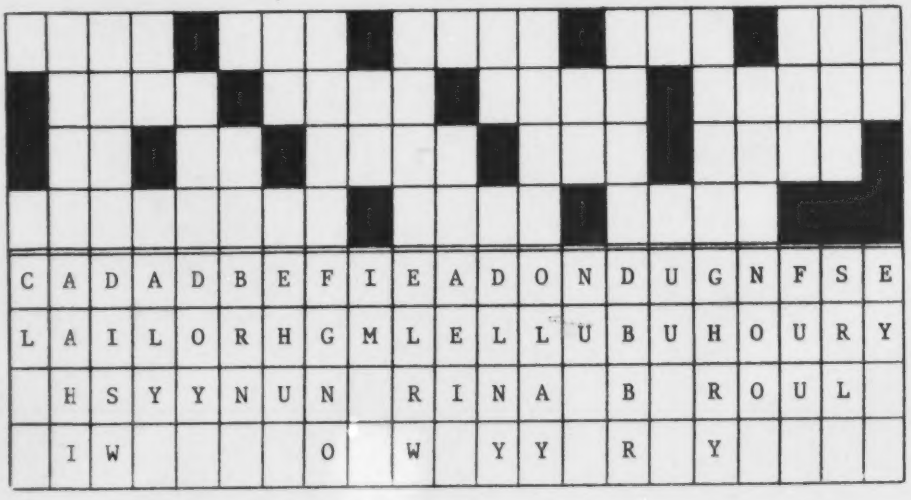
Challenge #2

If you wanted to cultivate lots of cockroaches in your house what would you provide to attract them?

Give a reason for each of your ideas.

A R S O N !

This puzzle conceals a piece of advice for one of our beneficial insects. To find the advice, transfer the letters underneath the diagram into the squares directly above them. The letters are all in the correct columns but not necessarily in the order in which they are to be moved up. The black squares indicate spaces between words.



C	A	D	A	D	B	E	F	I	E	A	D	O	N	D	U	G	N	F	S	E
L	A	I	L	O	R	H	G	M	L	E	L	L	U	B	U	H	O	U	R	Y
	H	S	Y	Y	N	U	N		R	I	N	A		B		R	O	U	L	
	I	W					O		W		Y	Y		R		Y				

Answer: Lady bug, lady bug, fly away home. Your house is on fire and your children will burn.

10. ANTS

Background

Ants, wasps, and bees belong to the same Order of Insects, the Hymenoptera. Hymenoptera have 4 wings, the rear wings usually smaller than the fore wings. Often they have narrow waistlines and fairly long antennae. The Hymenoptera include many of our beneficial insects as well as many social insects. In the Order Hymenoptera, ants belong to the Family Formicidae.

Ants are social insects living in large colonies. The queen is winged, the largest ant in the nest, and the mother of the whole colony. The males are smaller, winged, and usually die or are killed after mating. The large bulk of the colony consists of the wingless, infertile female workers. Most ants are equipped with a stinger.

Most ants nest in the ground where they excavate elaborate tunnels and galleries used for food storage and brood chambers. Above the nest, a mound is built of sand or soil excavated from the nest below. The food of ants varies with the species but most ants feed on plant juices and nectars, especially honey dew which they get by stroking aphids. Ants are not usually considered to be seriously harmful but they contribute their share to the discomfort of human beings.

Like ants throughout the world, ants in Hawaii come in several colors and sizes.

The common, large, Black Ant likes fats and oils and dead insects better than sweets. Black ants have several queens per nest and frequently set up new nests, sometimes at some distance from the parent nest. They run into trouble when they try to set up a new nest in the territory of the fire ant.

Fire Ants are red and almost as big as the black ants. They are stay-at-homes, building huge colonies with their queen buried very deep in the soil with a small, or almost no mound at the soil surface. Fire ants eat fruit, seeds, and other insects. They get their name from the vicious sting they can deliver.

Crazy Ants run about rapidly this way and that as if they were demented. They are small, black, shiny, hairy, and often make colonies in cracks and holes in kiawe trees and between the leaf bases of pineapple plants. They cultivate mealy bugs, scales, and aphids for food. Crazy ants can put up a good fight against fire ants in the event of nesting too closely.

The Argentine Ant loves sweets. It is small, dark brown, and has made itself into a household pest since it arrived in Hawaii about 1940.

The big, red Carpenter Ants are the giants of the ant world. Their queens may be as long as ½ inch. Carpenter ants may tunnel into wood to build their nests but are not as destructive as termites. For food they forage at night for sweets and other food stuffs in the kitchen. Colonies are small in size. They like to nest in hollow doors in the home.

Laboratory Maintenance

Many ant investigations can be carried on out-of-doors without the need of capture or maintenance of a laboratory colony.

Capture: Dig a moat around an ant hill. Then with a large shovel, overturn the hill in one large chunk. Look for brood chambers, food galleries, and look for the queen, but do not spend so much time looking for the queen that meanwhile the ants have carried off the grubs and disappeared. If only workers are brought back to the classroom nest, they must continually be replenished with new captures. To establish a permanent classroom nest, you need the queen and grubs, or at least some grubs from which some new reproductives may emerge.

Cage: An artificial classroom nest may be called a formicarium (after the scientific family name for ants).

So much literature on how to build and maintain classroom colonies exists that it would be redundant to repeat the long descriptions here. See your library.

Among the different types of formicariums described in books are:

-"Ant Farms" sold in pet shops as ready-made kits, ready to install the ants.

-Two panes of glass fixed about ½ inch apart and sealed on all sides except for two small openings for food and water entrance. The space between the two upright panes is loosely filled with soil from the ant colony.

-Two glass jars, one inside the other, with the narrow space between the two glass walls filled with soil from the ant nest. The inner jar is empty but contains a supply of any food and water and a ladder so the ants can crawl up and down into the inner jar.

-Elaborate plaster of paris tunnels and chambers set up to imitate an ant nest below ground. The side of the chambers are covered with glass to permit viewing.

In general, ant nests must be kept dark so that the ants will work next to the glass. They are uncovered only at viewing times.

Food: Food varies with species. Try #50, 51, 53, 55, 56, 57, 60, 61. Also try the stem of a plant which is covered with aphids.

Experimental Procedures: See PROGRAM MANUAL

Student Reports: See PROGRAM MANUAL

Investigations with Ants

1. ANT MOUNDS ON THE CAMPUS Bands 1, 2, 3

Problems:

How many ant mounds can you find on your campus? or at least around your own classroom building?

How many ant mounds can you find in and around your garden at home?

What colors and sizes of ants live in the mounds you find?

Are all the mounds you find of the same kind of ants?

Do ants of different kinds have mounds near to one another?

Look at enough different kinds of ant mounds so that you can learn to tell which kind of mound belongs to which kind of ant. You may become expert enough to be able to say on sight, "This mound belongs to such or such an ant."

Suggestion:

Sketch a rough map of the campus and place a dot to mark the location of each mound you find. Use a different color dot for each different kind of ant mound.

2. ANTS-OUT-OF-DOORS Bands 1, 2, 3

Problem:

How do ants behave when they move around outside the nest?

Suggestions:

Watch ONE ant for a few minutes to see where it goes and what it does.

Place a dab of honey or other food particles near an ant nest. How long does it take ants to come? Is there any evidence that one ant comes, then tells others to come?

Brush "several inches" of ants out of a line of ants. Does this break the line so that the ants coming from behind cannot find the way? Or do they know where to go?

With water or some strong smelling liquid, wash part of the pathway of ants. Does this destroy the ants' sense of where to go? Can they reestablish the path? If so, how long does it take?

What would you say is the method used by ants to find a trail: information obtained from other ants? smells along the trail? invisible markings along the trail? the sight of where the ant ahead is going? How can you test for each of these ideas?

3. ANTS VERSUS ANTS Bands 2, 3

Problem:

How do different kinds of ants behave toward one another?

Suggestion:

Collect many ants of one kind from a mound and put them onto the mound of a different species of ants. What happens? Do the visitor ants wander off unmolested? Do they become friends with the ants whose home they are on? Does a fight develop?

4. A FORMICARIUM Band 3

Problem:

Can you establish an ant colony in your classroom?

Suggestions:

Consult the library for directions on how to construct a classroom formicarium. See if you can keep a colony of ants flourishing in it.

5. ANT DIET Band 3

Problem:

What is the favorite food of the species of ants in your formicarium?

Suggestions:

Different kinds of ants like different kinds of foods. Big Black Ants like oils and fats and dead insects. Argentine Ants like sweets. Food #61 is supposed to be an excellent ant food. Do your ants like it?

PUZZLE FOR VERY YOUNG ENTOMOLOGISTS

When the teacher recites the "poem", can the children add the last word? Each blank stands for something related to insects.

1. I saw a rainbow flutter by.
   It was a lovely _____(butterfly).

2. It's worth a costly concert ticket
   to hear the singing of a _____(cricket).

3. Something's spoiled here! Somethings's evil!
   The flour bag has got a _____(weevil).

4. It bites and it's small and it isn't a mouse.
   It likes to get into your hair. It's a _____(louse).

5. Zzzzz, Zzzzz, wild and free.
   A nectar-sucking _____(honeybee).

6. Those big black bulges seen on flies
   beside the head are _____(compound eyes).

7. "Please eat your picnic lunch." "I can't,
   it's already eaten by an _____(ant).

8. Do you know when the grasshopper sings?
   It's when he flutters his big, wide _____(wings).

9. Like a velvet shadow by light of moon
   a moth emerged from its _____(cocoon).

10. Get the swatter! Make a try!
    If you don't miss you'll get that _____(fly).

11. BEES

Background

Bees belong to the Order Hymenoptera along with wasps and ants. Most bees are social insects who live in colonies comprised of a queen, drones, and workers. Bees have sucking or licking mouth parts and live on the nectar of flowers.

Two conspicuous bees in Hawaii are Carpenter bees and Honey bees.

Carpenter bees are large, hairy, and heavy bodied. The females are jet black with irridescent wings. The males are brownish yellow with transparent wings. Both males and females visit flowers very industriously and collect the nectar. They drill tunnels in wooden posts and other wood to make their nests.

Honey bees are a pale color and much smaller than Carpenter bees. Honey bees are one of man's most valuable domestic insects. Their stores of honey are tastey and nourishing food; the wax they produce makes candles and other objects; their visiting of flowers pollinates fruit trees and garden flowers. Domestic honey bees have been kept in hives for thousands of years. Because of this, there is a sizeable literature on bees, including many children's stories. The students may enjoy reading or hearing whichever bee stories happen to be in your library collection.

Bee Keeping

Suggestions for setting up a class bee hive are not given here. A teacher or class having the ambition to start a hive on the school campus is advised to find a professional bee keeper in the local community and follow his advice about which books (there are many) give the best directions for starting and maintaining the hive, where and how to obtain a hive and a swarm, and how to care for the combs. Most teachers feel that bee keeping is a job to leave to the professionals. It seems overwhelmingly complex and precarious. On the other hand one of our 7th grade Honolulu teachers is an experienced bee keeper and she claims the hobby is both simple and rewarding.

The investigations given below involve bees which happen to be visiting the school campus.

Not much is said in this manual about insect stings, chiefly because the problem is not serious. Most of us can live with mosquito bites and even with wasp and bee stings with only minor discomfort. However, a few people suffer a severe reaction to insect bites, especially bee stings. It is well for the teacher to be alert to the possibility of having one such allergic student in the class, and to take precautions accordingly.

Vocabulary (to be used as desired)

The scientific name of the honey bee is Apis mellifera, the "Carrier of Honey."

A person who raises bees is called an apiarist, or apiculturist. He keeps his bees in a hive or apiary. He is engaged in the business of apiculture.

Bees are social insects. They live in colonies with a division of labor among the different classes of members. The three classes or castes, are queen, drone, and workers.

Bees gather nectar from flowers. Bees show a flower constancy, meaning they gather nectar during one season from only one flavor or odor of flower. When the hive is full, or a new season begins, they may switch to a different flavor.

Bees also pick up and transfer pollen from one flower to another. pollen is pronounced to rhyme with "fallen" rather than with "stolen." Some pollen is carried back to the hive in pollen baskets located on the rear legs of the worker bees.

Activities and Investigations with Bees

1. A STORY FOR PRIMARY CHILDREN ABOUT QUEEN MELLIFERA AND HER SUBJECTS
Band 1

Consult an encyclopedia or the library for detailed facts about the life and honey gathering habits of bees. From this background you might elaborate a story for the young children which could go something like this:

"Once upon a time there was a beautiful and gracious queen named Queen Mellifera, who ruled over 10,000 subjects in a land of many fruit trees and beautiful flowers. (Describe the area to agree with your campus or neighborhood.) Queen Mellifera was fed and waited upon by her devoted subjects. They brought her honey, bee bread, groomed her . . . (Describe process). Every day the queen laid eggs in waxen cells prepared to receive them. (Draw six-sided wax cells on board and show the queen going from cell to cell, laying an egg in each cell.) Tiny, baby bees hatched from the eggs. Nurse bees cared for the babies and brought them honey and bread; kept them cleaned and fanned the nest . . . (Describe the work of the bees inside the hive.)

One day Queen Mellifera said, "Our hive is too small for our great numbers. Let us find a new nest and begin a new colony." (Give the children a part of the action by having them gently wave their arms and hum Zzzz, Zzzz to imitate the sounds of swarming. Then arm waving and humming can subside to indicate settling of the swarm into a new hive.)

Another chapter of the story could be about the worker bees gathering nectar in the field; stuffing pollen into their baskets; carrying pollen from flower to flower; bringing their loads to the hive; dancing to tell the other bees where to go; danger from being almost eaten by a bird or caught in the insect net of one of the students, etc., etc.

2. BEE LIFE HISTORY Bands 2, 3

Problems:

What different kinds of bees (castes) live in one hive?

What are the different stages in the life cycle of a bee?

What do bees do inside the hive?

What do bees do in the field?

Suggestion:

This could be an encyclopedia and library assignment for older students with the work divided among different groups. Oral reports from each group on their share of the assignment should be accompanied by drawings or other visuals.

3. ESTABLISHING A BEE VISITING STATION Bands 2, 3

Problems:

Which color, size, and shape of paper flower can attract bees?

Can paper flowers scented with honey attract bees?

If not, can you find some artificial way to attract them?

If so, what colors, shapes, sizes, kinds of scents, attract them most?

Suggestions:

Cut out circles of different colored paper to represent flowers. Include blue "flowers."

Place a dab of nectar (diluted honey-water) in a tiny wax cap in the center of each "flower."

Put the "flowers" in your open classroom windows or in some other area you choose to develop as your bee visiting station. Be sure the spot is conveniently located for watching.

4. TRAINING WILD BEES Bands 2, 3

Challenge:

Can you lure a bee to follow you and come to visit a honey station?

Suggestions:

Place a drop of honey on the end of a chopstick (or twig, or knitting needle).

Hold the honey-tipped stick close to a flower where a bee is visiting. Perhaps when the bee finishes sucking the nectar from the flower it will visit your stick.

Sometimes the stick has to be stuck right onto the bee to get its attention.

Carpenter bees are sometimes lured more easily than honey bees.

When the bee is interested in, or stuck to, your stick, gradually move away. Bring the stick and bee with you to the spot you choose to be the bee-visiting station. Leave the stick, honey, and bee there at the station.

The bee will go away, but if it liked what it tasted, it will tell other bees to come to the new honey source.

After you have attracted many bees to come voluntarily to your station, you can do some of the following experiments.

5. FLAVOR AND ODOR PREFERENCES OF BEES Band 3

Problem:

Which odors and flavors of sweets do bees like best?

Suggestions:

Make up solutions of sugar and water, honey and water, and other sweet solutions or sweet nectars of your choice.

Place these in the "flowers" which you found from Experiments 3 and 4 that bees like best. Will they accept an artificial sweet such as saccharine?

6. TRAINING BEES TO TELL TIME Band 3

Problem:

Do bees have a sense of time?

Suggestions:

After you have attracted a group of bees to visit your station regularly, put out sweet nectar for them only for one hour each day. Do they learn to come looking only at that hour or do they keep coming all the time until they find something?

If they show signs of having learned to come only at one time, change the time and see how long it takes them to learn the new time.

7. THE INDUSTRY OF ONE BEE

Problem:

How often does the SAME bee come back for a new supply of nectar?

Suggestion:

While a bee is busy sucking nectar at your station, mark it with a small dab of paint. Mark several bees, using a different color for each.

Check how often the same marked bee returns to get more nectar.

E L Z Z U P G N I L L E P S

The letters in the following words can be changed around to make the names of things applying to Insects. Answers on page 50.

1. Change GELS into structures insects can walk on.
2. Join the letters of NEAT NAN into one word for insect feelers.
3. Change STRAIN into a stage of insect metamorphosis.
4. Add an E to LATHERS and turn it into something flies have instead of rear wings.
5. Put an E with STRING and make it into an insect weapon of war.
6. From BLISTERS you can get the stiff hairs on insect legs.
7. If you put an M with LOST you can turn the letters into something an insect does when it changes its coat.
8. If you put a W with SIGN, an insect could fly away with it.
9. When the grocery store advertises NO COCO in stock, moths can use the letters to build themselves a house.

12. MISCELLANEOUS INSECTS

Background

Most common insects are happiest and offer us the best information about themselves when they are observed in their natural habitats in the out-of-doors. Many of these are insects we would like to say "Hello" to and perhaps call by name when we happen to meet them, even though we do not capture or cage them.

Below are some such common insects and a few points about them which might be observed. For the younger children this gives opportunity for telling or writing stories about them, or just noting their movements and locations from day to day. The older students might be stimulated to go from seeing the insects in the wild, to the library to find further information about them.

The information below is provided in a fashion which gives background for teachers to make up stories for the younger children. Perhaps you know some insect songs the children could sing, with gestures.

For older students, the paragraphs about each insect include bits of inquiry which could be built into an investigation, perhaps in some cases a library search.

1. Earwigs Bands 1, 2

Earwigs are black, hard-shelled insects common in gardens in Hawaii. We easily distinguish them by their two cerci at the end of the abdomen which are enlarged to look like dangerous pincers.

Actually earwigs are non-poisonous and quite harmless. They live in cracks and crevices, particularly in spaces in plants such as at the bases of the leaves. They scavenge at night, or chew on parts of the plants in which they live. They like sugar.

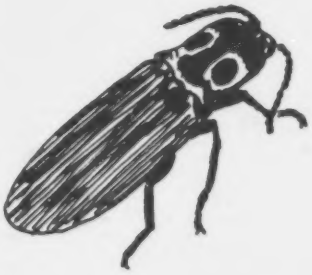
Earwigs belong to the Order of Insects called Dermaptera.

2. Ladybird Beetles Bands 1, 2

Lady bugs are not true bugs. They are beetles belonging, along with all the other beetles, to the Order of Insects called Coleoptera. Ladybird beetles come in beautiful colors. Most are orange with different numbers of black dots. Some are a beautiful, shiny blue.

How many different colors of Ladybird beetles can you find in your neighborhood? When you do find them, protect them and treasure them. They are good friends to the plants in your garden because they eat plant lice (aphids) and other plant pests. The Ladybirds lay their eggs among the aphids. When the colorful hairy larvae of the Ladybird beetles hatch from the eggs, they move about among the aphids, scales, mealy bugs, and other insects harmful to plants, eating them up one after another. In California, the citrus growers import Ladybird beetles in large numbers and put them out to live among the fruit trees to keep the trees clean from plant pests.

3. Click Beetles Bands 1, 2



Someday you may happen upon a hard-shelled, striped beetle (Coleoptera) which looks as if its body is hinged across the middle. Lay the beetle on its back on a hard surface. If it is a click beetle, it will suddenly jump or "click," leaping into the air, in an effort to turn itself right side up.

Play with your click beetle for awhile and see what you can find out about it. Does it always land on its feet after it clicks? If you keep turning it over onto its back does it get tired and stop? Or does it get excited and click more often? Measure how high it jumps when it clicks.

4. Praying Mantis Bands 1, 2, 3

Praying Mantises, or Praying Mantids if you prefer, belong in the same Order of Insects as grasshoppers, crickets, and cockroaches, the Orthoptera. You can walk right up to a Praying Mantis and say "Hi" and it will just look at you without budging an inch. If you offer it a sample of its favorite food, another living insect of some sort, it may or may not decide to eat it. If and when it makes up its mind to accept the meal, it grabs the victim in its powerful front legs and bites it in the back of the neck.

Praying Mantids are not above eating other Praying Mantids, if they happen to be handy. One handy victim is the male mantis when he comes to mate with the female. The female usually eats her partner after mating and sometimes she begins her meal before the mating is finished.

The egg cases of Praying Mantids look like gray chunks of dry foam attached to a twig on a bush. If you find one, bring it in and see how many baby mantids hatch out. Compare their appearance to their parents. If you keep them all in the same cage you will soon have a reduced population because some of them will be inside the stomachs of the others.

You might enjoy teasing a Mantis to see how close you can get before he or she backs off or strikes back. But don't harm the Mantids. They are numbered among our friends because they eat insect pests.

5. Grasshoppers Bands 2, 3

If you would like to raise grasshoppers, follow the same instructions for caging and care given for crickets. They belong to the same Order of Insects and have the same kind of life history except that the grasshoppers are a little harder to feed and care for.

Grasshoppers come in different sizes with different lengths of antennas. We have several species of grasshoppers in Hawaii. You might like to see how many different kinds you can catch. When you are finished looking at them or sketching them, the farmers and gardeners will be glad if you kill them instead of letting them go.

6. Termites Bands 1, 2, 3

Look for flying termites on May evenings at dusk. They flit about uncertainly on their delicate wings looking for a mate. When they find one, they drop to the floor or ground. If you watch carefully you can see them purposely flick off and detach their wings. Then they crawl away together, the female following the male, searching for a crack in wood or a nail hole in which to make a nest and begin a colony.

A fully developed colony includes the founding pair who become the king and queen, and all their children. Most termites grow up to be workers. The workers eat tunnels into wood to enlarge the nest and provide food. Some young termites grow to be soldiers who guard the nest with their big strong jaws. A few termites become helper or secondary kings and queens. They are smaller than the royal pair but they help in egg laying.

In Hawaii we have dry wood termites which live in furniture, and ground termites which have their main nest deep in the ground. More than a million termites may belong to the same ground colony. They bore their way up into houses or into the wood of trees and hedges.

You may never see a queen termite or a main termite nest because they are so well hidden. But if you want to test to see if you have ground termites in your area you might drive a new piece of wood into the ground. About once a month, dig it up and check to see if the termites have found it yet.

Termites belong to the Order of Insects called Isoptera.

7. Leaf Miners Bands 2, 3

The leaves of nasturtiums and beans, and sometimes other leaves may show squiggly lines of a lighter color marked into them. Pick such a leaf and hold it up to the light. Look at it closely with a hand lens.

What has happened is that a small insect has gotten in between the upper skin and the lower skin of the leaf. It eats its way around inside the leaf, leaving behind it an empty tunnel. Look at the end of the line. You may be able to find the insect going about its business of eating out more tunnel space.

Many different kinds and Orders of Insects may mine the insides of leaves. Some belong to the moth and butterfly Order (Lepidoptera). Some are certain kinds of fly larvae from the Diptera or Hymenoptera. Some beetles (Coleoptera) are great eaters of the insides of leaves and stems.

8. Aphids, Leafhoppers, Whiteflies, Mealybugs Bands 2, 3

All of these insects belong to the same Order of Insects, the Homoptera. Most of them are small "sitting down" insects which stay in one place and hardly move about at all.

Aphids are sometimes called plant lice. They look like little bumps, larger than pin heads, scattered along the tender green stems of plants. They just sit still and suck the juices of the plant, which does not do the plant any good. Their fat little bodies give off a sweet juice called honeydew which ants like. Look on the newer stems of hibiscus bushes or other plants for aphids. Perhaps you may also see ants running along the stem visiting the aphids and licking them.

Leafhoppers are not so commonly seen in Hawaii now, but once they were such a plague they almost wiped out the sugar industry. They were brought under control by introducing insects which destroy leafhoppers. Leafhoppers are very small insects which fold their green or straw-colored wings together so that they seem to be part of the stem or leaf. While they rest they busily suck the plant juices.

Whiteflies are the curse of our tomato and vegetable farmers. The nymphs of the whiteflies congregate on the underside of vegetable leaves in such thick colonies that they cover the whole undersurface of the leaf. They suck out the plant juices, leaving the plant dry and too weak to produce a good crop. Look on the underside of some tomato leaves and see if you can find some. The Hawaii Agricultural Experiment Station is developing strains of vegetables which are resistant to Whitefly attack.

Mealybugs used to be a problem in pineapple fields and sometimes they still are a problem there as well as among garden plants. Mealybugs look like little white bumps of

cotton or white powder stuck to the plant stem, especially in the cracks. Like their pesty relatives, they suck out the plant juices.

9. Mealworms Bands 1, 2

Mealworms (Tenebrio moliter) are the larvae of a beetle which possess several excellent points which recommend them to elementary teachers, even though grain merchants take a dim view of "critters" which thrive on their stored crops. A mealworm culture in the classroom is odorless, takes only the space of one glass container, requires practically no attention or maintenance care, provides a continuous food supply for the classroom chameleon, frogs, or toads, and best of all, delights the children who tend the larvae.

To get started, put a few cups or quarts of oatmeal (uncooked, dry) into a glass container such as a gallon glass jar or an old aquarium. Add crushed dry dog biscuit to balance the diet. Buy a few mealworms from a pet store and put them into their new home. From time to time lay a slice of raw carrot or raw apple or the equivalent on top of the meal, but remove the slices before mold sets in. These provide ample moisture. No water is required. The larvae pupate in the meal and emerge as sluggish, hard-shelled adult beetles. Keep a screen over the top of the jar so that the adults cannot fly out. Eggs are laid in the meal and the life cycle continues.

About once a year you may wish to set up a new jar of oatmeal and transfer the mealworms to it, discarding the old meal which by that time begins to build up a bottom layer of powdery wastes.

During the test year before publishing these experiments, two primary teachers tried giving their students each their own mealworm culture to watch. Each student had a covered petri dish containing some oat meal and 1 or 2 mealworms. In one class, the students took great personal interest in their personally-owned pets, lifting them out daily to check on their well being and rearranging their "beds." In the other class, questions arose on how the mealworms could "breathe" with the lid on the petri dish. The teacher wisely refused to assist with the problem except to repeat, "Well, how do they get air with the lid on?" This led to considerable discussion and hypothesizing not only about mealworm respiratory requirements, but about air and types of closed containers.

Rearrange the letters of the NICEST word in English to spell a small flying creature.

(Answer: INSECT)

13. MISCELLANEOUS INSECT INVESTIGATIONS

Background

The following brief activities involve physiological reactions using insects of several kinds.

Methods for capture, laboratory caging, feeding, and care of the insects needed for these investigations can be taken, as applicable, from the general directions in Section 2.

You may wish to give the students only the problems outlined in the box and let them figure out for themselves how to solve the problems, especially the older or more creative students. The suggestions can be given to the students as needed.

1. COLOR SENSITIVITY Bands 2, 3

Most insects can see very well and are especially sensitive to any movement which takes place in front, on either side, or even in back of them. But insects do not always see the same range of colors or colored light which we do.

Problems:

Which colors do insects see best?

Which colors do they seem not to see?

Suggestions:

Use traps #21, 22, or 23. Use light bulbs of different colors in the traps. Perhaps a string of Christmas tree lights could be distributed within a row of adjacent traps.

Place dabs of insect food on pieces of paper of different colors. Then after awhile remove the food and see if they come looking for food on some colors more than others.

(Teachers note: In general, insects are blind to the red end of the spectrum, i.e. they cannot see red light or red objects. They are more sensitive than we are at the blue and ultraviolet end of the spectrum.)

2. JUMPING DISTANCES

(Simple observations for Band 1. Math inserted for Bands 2, 3.)

Problems:

How tall are you?

How far can you jump compared to your height?

Measure the lengths of some jumping insects such as grasshoppers, crickets, click beetles.

How many times their own length can they jump?

If you could jump that many times your own length, how far or high could you jump?

3. ATTRACTION OF MALE FLIES Bands 1, 2

Male house flies readily jump onto female house flies in flight. Male flies seem to be not very discriminating, or smart, or sharp sighted. They will jump onto (mount) anything which faintly resembles a female in flight.

Problem:

Can you catch a male fly with an artificial female?

Suggestion:

Make a ball of black fuzz or use a black bead about the size of a house fly. Smear the object with vaseline or "Tanglefoot" or any glue which stays sticky. Hang the "fly" from a very fine, almost invisible, thread so that the breezes waft it gently to and fro. See how long it takes a male fly to jump onto your trap.

4. PREENING AND CLEANING Bands 1, 2, 3

Flies, grasshoppers, praying mantises, and many other insects clean their legs and antennae by rubbing them or brushing them one over the other. This is called preening or grooming.

Problems:

Watch some insects groom themselves.

Do preening insects follow a special routine in cleaning themselves?

Do they always start with the same legs or other body parts and do it the same way each time?

How does insect grooming compare with how cats wash themselves?

How do we human beings groom ourselves?

5. LIGHT VERSUS DIRECTION Bands 2, 3

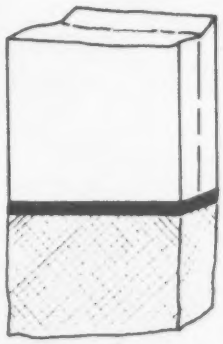
When a bag net (Net #11) is clapped over a bush, many small flying insects rush upwards to the light area at the top of the bag net.

Problem:

Which is the first reaction to fright, the flight upwards, or the flight to light?

Suggestion:

Make a small size Bush Bag Net #11 but put the dark part at the top and the light net at the bottom. It could be made, for example, by attaching a net "skirt" to the bottom of a large brown paper grocery bag or dark cloth bag.



Quickly clap the bag over a potted plant or cage full of small flying insects. Observe whether the insects fly upwards first, and stay there; or upwards first and then come down seeking the light; or to the light first and stay there; or to the light first and then crawl upwards; or is there a noticeable preference?

6. SPEED OF INSECTS Band 3 with math

Flying insects move too rapidly to permit measurement by visual means or with crude instruments, but crawlers go slowly enough to measure.

Problems:

How fast does an ant run along its path?

Do they always run at the same speed?

How fast does an inch worm crawl?

If you put an insect into a place it does not like, such as in too much light or warmth, how fast will it crawl or run to a nearby place it likes better?

Problems (cont'd):

How fast does a hungry insect run or crawl to its favorite food?

When an insect crawls or runs along a flat, horizontal surface, does it go at the same speed, or faster, or slower, than when it goes up or down a vertical stick or stem? Maybe it isn't the direction, maybe it is something else which determines the speed?

For what various reasons do insects stop along the way as they run or crawl?

What is the longest distance you can get an ant or other insect to go without stopping? Who holds the record?

Suggestions:

Stretch a tape measure or ruler on a path along which an insect is moving. Using a watch with a second hand, time how long the insect takes to get a certain distance.

Distance ÷ Time = Speed

Ants might be measured in inches or centimeters per second. Slower crawlers might be rated in inches or centimeters per minute.

How will you handle the difficulty of gaging the speed of insects which go unevenly or stop along the way? Perhaps only those portions of the journey should be measured which include no stops. Perhaps the entire journey, including stops, should be timed and the average speed calculated.

Cockroach races have been held at times at Kapiolani Park. Cockroaches are put on race tracks covered by plastic tunnels. Enter the Kapiolani Park Cockroach Race; or have a class or school cockroach race.

SECTION 4. METAMORPHOSIS, ANATOMY, CLASSIFICATION

Introduction

The following group of topics on INSECTS concern metamorphosis, insect anatomy, and classification. These topics are placed last in the INSECT series because only after students have observed a number of insects are they in a position to contribute from their own experience to a discussion about varieties of insect body types and behaviors.

The strategy here is to avoid as much as possible an information-giving lecture; instead use a sharing, discussion approach. How much discussion can be drawn out of students will depend not only on the extent of their background, but also on their grade level and ability.

As a rule of thumb:

1. Draw as much information as possible from the students' previous observations and investigations.

2. Add some points of further information and vocabulary to what they already know to give them a sense of learning something new and adding to their knowledge. Give as much information as the students show an eagerness to learn.

3. Stop before you have told them "more about insects than they care to know." Leave something for the high school biology teacher to do!

As you become acquainted with these concluding topics, you will see ways of distributing the information they contain among insect topics earlier in the year. For example, earlier work with butterflies or moths may provide a point of departure for getting into metamorphosis; or the study of bees or ants or termites could precipitate a digression into social insects in general. Mosquitoes could lead to talk about disease vectors of other species.

If such observations and discussions are covered earlier, these last topics can either be skipped (because they have already been done) or they can be used as a review and wrap-up.

1. METAMORPHOSIS

Background

Most insects undergo dramatic changes between hatching and maturity. The series of changes is called metamorphosis.

The activity on metamorphosis as described here becomes do-able if the students have previously observed some insects which show changes of various kinds.

Problem:

What changes do insects undergo between the egg stage and adulthood?

Procedures-in-Brief

1. Help students recall the changes they have observed in whatever insects they have studied thus far.

2. Develop a written list of the kinds of changes which have been observed during insect growth. Help students to note that not all insects follow the same scheme or pattern of changes.

3. Clarify the types and stages of metamorphosis. Do some vocabulary work.

Procedures in Detail

1. Help students to recall insect changes they have observed previously.

   Have students flip back through their notebooks to recall what insects they have investigated and what changes they noted in their life cycles or growth patterns.

   Solicit further information about insect changes gleaned from memory or stories or books they may have read.

   Put a random list on the board of the changes they have noticed, e.g. moths came out of cocoons, baby flies looked like worms, baby stinkbugs changed color at each molt and finally got their wings at the last molt, etc., etc.

2. Rearrange the random list, with student help, in some kind of order, lumping together kinds of changes which seem to belong together.

Can the students recall some changes which seem similar to other changes, e.g. caterpillar to cocoon to moth resembles caterpillar to chrysalis to butterfly.

Fly maggots, beetle grubs, and most other larvae seem to start life as "worms." Stinkbugs, crickets, grasshoppers have young which bear some resemblance to the adults (at least they are not so wormlike), and so on to noting other groupings of similar changes.

Try to bring as much organization and relationships into the list as possible, working with the students' ideas rather than your own sense of knowing what is coming.

3. Using examples from the student lists, teach the stages of complete and incomplete metamorphosis. Take whatever vocabulary is needed to fit the student list.

Young students usually like to learn and show off their ability to use new big words so you may be able to hold their interest for quite awhile just with tacking proper terms onto their list of changes. On the other hand, there is a limit to how much they can learn at one time.

The vocabulary list below is intended to be extensive enough to fill the needs for upper level, bright classes with good background. Pare it down to fit your students' needs and ability levels.

Background Information and Vocabulary for Teacher's Reference

The first stage of insect life begins with the egg.

Eggs hatch into small creatures with big appetites. These small creatures grow, going through different kinds of changes, to adulthood. The series of changes they undergo is called metamorphosis. (Greek: meta = many, morphos = form).

Sometimes they go through many drastic changes in shape, color, and behavior. This is called complete metamorphosis, e.g. butterflies and moths.

Sometimes the changes are less striking, with some changes skipped in the growth process. This is called incomplete metamorphosis, e.g. crickets.

In some insects, the babies look just like the adults, only smaller. In such cases it is said that the insect has no metamorphosis, e.g. silverfish.

The Stages of Complete Metamorphosis are as follows:

The tiny creature which comes out of the egg is worm-like. It is called a larva, plural = larvae.

Larvae are sometimes given special names:

The larva of a moth or butterfly is a caterpillar.
The larva of a fly is a maggot.
The larva of a mosquito is a wriggler.
The larva of a beetle is a grub.

When a larva reaches a sufficient size, it encloses itself in a protective covering. Then it is called a pupa (plural pupae) in a pupal case, or puparium.

Pupae and pupal cases sometimes have special names:

The pupa of a moth is enclosed in a cocoon.
The pupa of a butterfly is enclosed in a chrysalis (plural chrysalides).
The pupa of a mosquito is called a tumbler.

While the pupa is keeping quiet inside the pupal case, it is busy changing into adult form. The adult form is sometimes called an imago (plural imagines or imagos). The adult has wings and has usually changed its chewing larval mouth parts to sucking mouth parts.

How many insects have you studied which have complete metamorphosis (egg--larva--pupa--adult)?

The Stages of Incomplete Metamorphosis are as follows:

When the tiny creature comes out of the egg, it is not a worm, but neither is it entirely like the adult of the species to which it belongs. It is a young form called a nymph. Nymphs which live underwater, such as dragonfly nymphs, are called naiads.

A nymph grows bigger, sheds its coat, grows bigger, sheds its coat again, and so on through many stages. Shedding the coat is called a molt, or molting, or ecdysis (plural ecdyses).

The stage between molts in the larva or nymph is called an instar. The first instar is the stage between the egg and the first molt. The change between the first molt and the second molt is the second instar, and so on. Nymphs go through 4 to 8 or more instars before they reach maturity. From the last molt they emerge as adults with wings.

How many insects have you studied which have incomplete metamorphosis (egg--nymph--adult)?

No Metamorphosis

Sometimes the tiny creature which comes out of the egg is just like the adult, only smaller. To change to an adult, all it needs to do is grow bigger. In such cases, the insect is said to undergo no metamorphosis.

Do you know any insects which have no metamorphosis?

2. THE INSECT BODY

Introduction

This topic is a once-over-lightly study of the morphology of the typical insect adult body. As in the previous topic, the strategy is to draw out as much as possible from the earlier experiences and observations of the students so that this can be a student-shared lesson rather than a lecture.

There must be as many ways to draw attention to the details of an insect body as there are teachers. Use your favorite system. Below are two ideas, either of which you might like to use or adapt.

Work in vocabulary words as you go along. Children pick up words as they hear them used and explained.

1. THE HUMBUG Bands 1, 2, 3

Problem:

Can you make an insect?

The following pages show parts of insects. Duplicated or Xeroxed copies of these could be distributed to the students to be cut out, traced, copied, colored, or whatever seems desirable. Some students may prefer to draw their own parts rather than use those provided. The separate parts can be fitted together to make an insect.

A contrived insect which resembles a real, bona fide insect with all the right numbers and shapes of legs, wings, etc., can be called by the name of that insect and put on display as a "masterpiece."

An insect which comes out as "a new species" (e.g. a combination of grasshopper legs on a bee body with butterfly wings) is a HUMBUG. Humbugs also make good displays with discussion of what parts they are made of.

As the insects are being made, mention and talk about the names of the parts, number of each, how they fit together, what colors they are, etc. Most students get the wings and antennae matched up and properly placed. Very few students, even older ones, ever get the legs on right. Invariably they attach the legs to the abdomen instead of to the thorax. Watch for this and discuss it.

2. MODELS OF INSECTS Bands 1, 2, 3

Problem:

Can you make an insect?

Supply the students with art and craft materials of whatever kinds you have plus whatever the students can help to gather.

Using paper, felt, sponge, wood, pipe cleaners, tooth picks, clay, papier mache, poster paint, and/or what not else, let the students make an insect.

Since this is a science lesson, have the students COPY FROM A REAL INSECT. In science we aim for ACCURACY. Letting them sculpture an insect entirely out of their imaginations is not likely to teach them much about the parts of insects and how the parts fit together.

Watch for the legs. Where are they attached?

Some students may wish to work with immature forms of insects such as grubs, maggots, caterpillars. In these cases watch for leg number and arrangement (usually grouped at both ends), or the pointed head end in maggots, or special structures in naiads.

Answers to puzzle on Page 22:

Forward: cocoon, ladybeetle, nit, nymph, webworm, yellowjacket, (ant) lion.

Backward: ant, beetle, bug, cockroach, dragon(fly), tick.

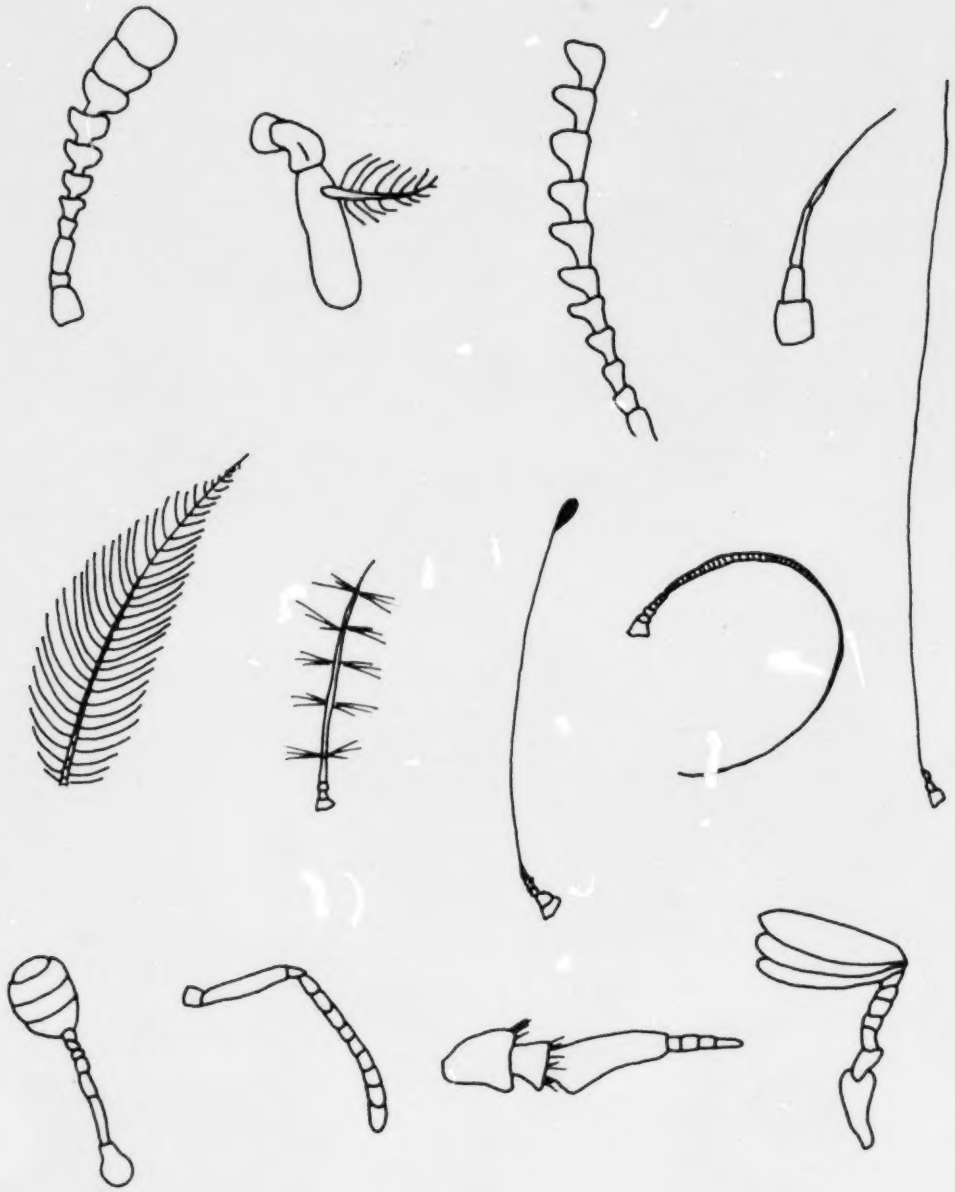
Upward: antenna, armyworm, chrysalis, fly, grub, leg, termite, weevil, wing.

Downward: cerci, damsel(fly), katydid, mosquito, waterbug.

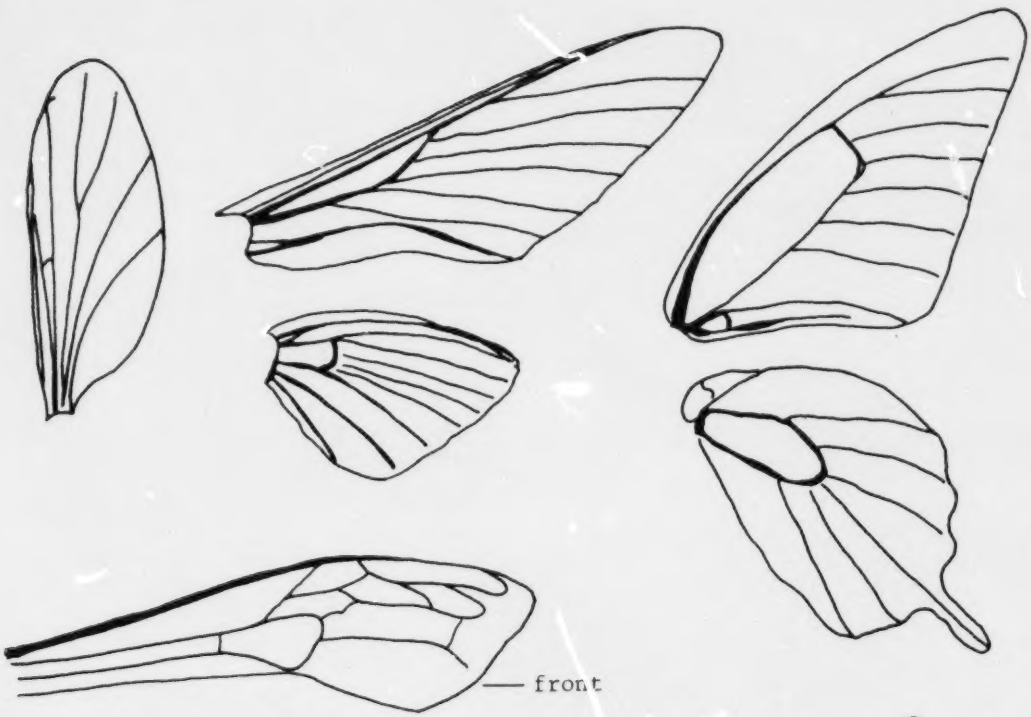
Diagonally: aphid, butterfly, carpenterbee, egg, eye, molt, wasp.

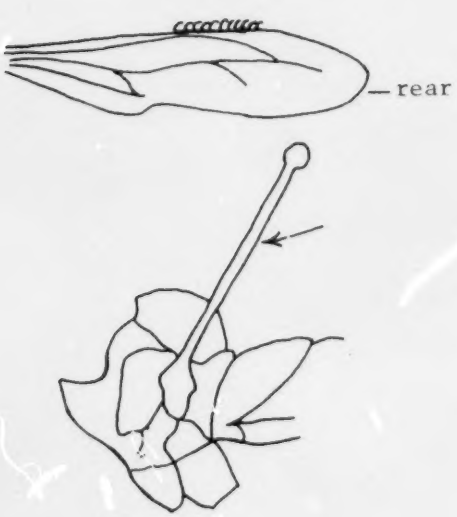
The 21 letters left after the letters needed for the above words are used, spell out INSECTS ARE INTERESTING.

ANTENNAE

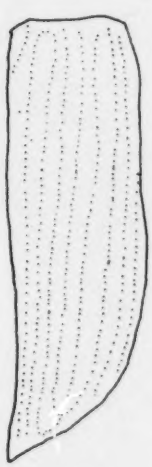


WINGS





HALTERE OF A CRANE FLY

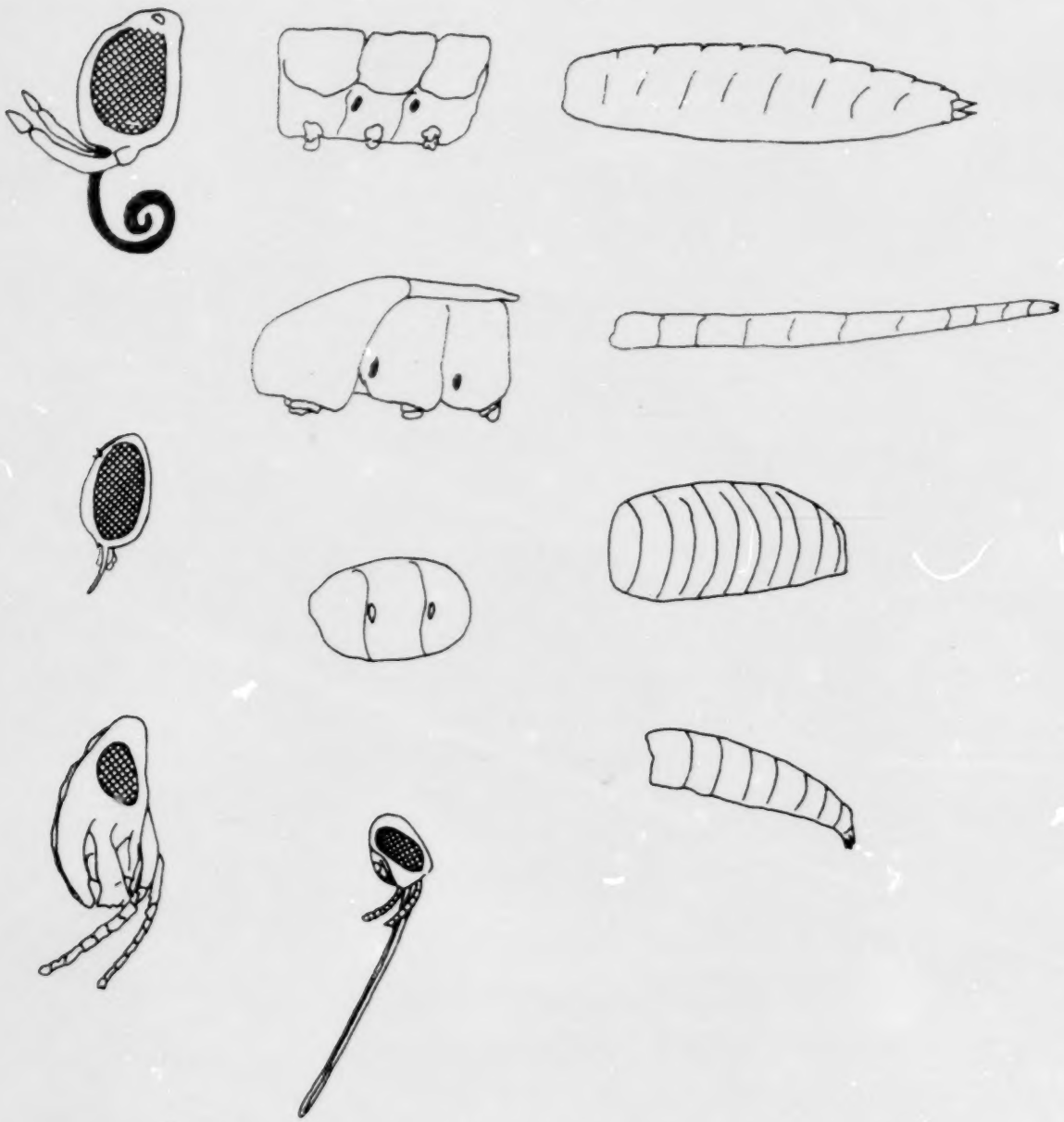


ELYTRON

TEGMEN

Legs

HEADS MIDDLES ENDS



3. WHAT IS AN INSECT?

Introduction

The models which the students constructed in the last topic can serve as a springboard for arriving at a definition for an insect.

Problem:

What body parts do all insects have in common (in the adult form)?

What is the definition of an insect?

Suggestions:

Compare the models the students constructed in the last topic. Try to pull together agreement among the students as to what all their insects have in common in their adult form.

What must a given animal possess in order to be considered an insect?

After the students have exhausted their ideas and built their own definition, you might share with them what entomologists have concluded constitutes an insect.

As agreed upon by entomologists, an insect is:

-A member of Phylum Arthropoda (Arthropods have jointed legs, exoskeletons, and segmented bodies),
-whose segmented bodies in the adult form are divided into three regions (head, thorax, abdomen), and
-whose six legs (always 6) and 4 wings (usually 4) are attached to the thorax.

Note that this definition eliminates spiders which have 8 legs.

For more extended discussion and the learning of more vocabulary, the following list is provided as teacher background information.

Adult insects have three body sections:

1. Head which bears:

-two antennae, feathered, hairy, smooth, bristly, knobbed, straight, curved
-two large compound eyes
-usually three simple eyes called ocelli (singular ocellus)
-mouth parts adapted for chewing with mandibles, maxillae, labium, labrum, or for sucking with proboscis

-two palpi, one on each side of the mouth

2. Thorax, to which is attached:

-two pairs of wings, marked with veins. The wings may be membranous like tissue paper and either naked or covered with colorful powdery scales. The forewings may be hard "shells" called elytra (singular elytron) as in beetles. The forewings may be thickened and leathery as in grasshoppers. In this case they are called tegmen (plural tegmina).
-six legs, each divided into several joints, with claws or pads at the ends
-two spiracles on each side. These are air holes for intake and outgo of air

3. Abdomen, divided into transverse segments (usually 11):

-spiracles or air holes, two in each segment
-an ovipositor in females at the rear tip for egg laying. In some insects, the ovipositor is modified to be a stinger.
-two cerci or clasps

The attachments to the three body sections are collectively called appendages.

The students may also get into special structures such as ear drums (tympanum, plural typani); bristles and hairs; modifications of leg structures such as combs, pollen baskets, stridulating devices.

EVERY INSECT

Adapted from Dorothy Aldis

Every insect (ant, fly, bee),
Is divided into three:

One head, one chest, one stomach part.
Some have brains. All have a heart.

An insect has no bones. It grows
By taking off its outer clothes.

It has no nose, but it can smell
With feelers. Can you do as well?

Also, you'd be in a fix
With all those legs to manage: six.

4. SORTING THE INSECTS - CLASSIFICATION

Background

When we human beings are faced with a large conglomeration of objects (such as several hundreds of thousands of species of insects) our human intelligence wants to group the vast array into categories with which we can more easily grapple.

Any assemblage of objects can be sorted into arbitrary groups by any set of characters we choose. We can sort by sizes (as stars), or by colors (as flowers), or by behavior (as with students sometimes). Traditionally, entomologists have sorted insects by body structure into Orders of Insects. There are other sorting criteria used by both entomologists and others. Farmers instinctively divide insects into those which are pests to their crops, and those which are not. A public health official might prefer to think of insects grouped according to their disease-carrying potential.

Setting up criteria by which to sort objects (including insects) is an arbitrary matter. This comes as a shock to many students. They tend to think that humans and rules, especially rules printed in text books, are infallible and supreme. Nature must comply with the man-made categories. Students often believe that if the text book or the scientific definition says, for example, that queen ants have wings, then every queen ant must have wings or there is something the matter with the ant! There is, of course, nothing the matter, nor even anything exceptional nor strange, about a queen ant which happens to belong to an entirely wingless species. The trouble is that our arbitrary categories and definitions do not completely fit the reality.

This exercise on sorting insects tries to get at something far more fundamental than teaching students the Orders of Insects. It attempts to bring students to some realization that sorting criteria are man-made and arbitrary, that such systems are fallible, that we run into trouble when we try to shoe-horn the broad continuums of nature into discreet packages, and that in the final show-down it is nature and not us which has the final say.

Having learned that lesson, or at least touched on it, the students are better prepared to understand some of the sorting systems used traditionally in science.

Problem:

How can we sort the insects we have studied this year?

Experienced teachers may have excellent ideas of their own for handling this problem. The following set of procedures is but one way of pursuing the points to be made.

1. Review with the class the various insects studied this year, using the student notebooks as reference. Ask the students to bring in pictures or descriptions of still other insects, so as to accumulate a large collection of kinds and varieties.

2. Talk about the likenesses and differences among the insects. Get a list going on the blackboard of common characteristics. Brainstorm for as many different categories as possible. For example the students might think of listing such types as winged, large, green, disease carrying, pests, tropical, parasitic, beetles, social insects, plant eaters, water insects, migrators, and so on and on.

3. Use each category as a column heading and ask the class to sort all their insects in the column to which they seem to belong. This leads to trouble and frustration. Some insects belong under two or more headings. Some categories are overlapping. Some headings are hazy in meaning. Some insects seem not to fit in any category.

   These frustrations can be discussed and can lead to the realization that the sorting of insects is based on arbitrary decisions, i.e. the sorting categories depend on human ideas and these have to be changed and adjusted to fit the insect situation. You cannot change the insects to fit the sorting system.

   Another lesson to be drawn here is that column headings must be chosen which are mutually exclusive. You cannot sort, for example, both by size and by color in the same system.

4. Pick out ONE system for sorting, e.g. suppose we choose, arbitrarily, to sort by size. (Or you could begin sorting by color, or by any other <u>one</u> characteristic.)

   The column headings for size might look like this:

Large Insects	Medium Insects	Small Insects

   Ask the students to sort their insects according to this size classification.

   Now another problem arises. How large is large? When do you put an insect under the medium column rather than the large or small? This points out the need to be <u>specific</u> in indicating column headings.

Try some other types of sorting systems with the students. In all of them the need will arise to be specific about the meaning of each column heading. From all of them, the lesson can be learned that systems are subject to human interpretation, that insects "do their own thing" without regard to making themselves fit neatly into our artificial systems.

5. After the students have learned the points to be made by the above exercises, you may wish to teach them some of the sorting systems and classifications which scientists have arbitrarily chosen for insects.

How many of the following systems you wish to discuss with the students and in what detail, will depend on student interest and ability, as well as time you wish to put into it.

A. SORTING INSECTS BY BODY STRUCTURE.

Within Phylum Arthropoda, Class Insecta is divided into about 22 to 27 orders depending on the author.

Common Orders which students are apt to encounter include:

Thysanura: No metamorphosis. No wings. Chewing mouths. Example - silverfish.

Odonata: Large, stiff-winged. Very large eyes. Example - dragonflies.

Orthoptera: Long, narrow front wings and wide frail hind wings. Hind legs often large for jumping. Mostly chew plants. Example - grasshoppers, crickets, roaches, mantids.

Isoptera: Fore and hind wings same size. Chew. Colonial. Example - termites.

Dermaptera: Short leathery fore wings. Large claspers. Chew. Example - earwigs.

Anoplura: Wingless. Flat bodies. Parasitic. Example - sucking lice.

Hemiptera: Leading edge of front wing leathery while rear portion of front wing is membranous and overlapping across top of body when at rest. Piercing-sucking. Example - Bugs, e.g. stink bugs.

Homoptera: Plant sap suckers. Often wingless. Example - aphids, whiteflies, scales.

Coleoptera: Front wings are a hard "shell" over top of body and meet in straight line down center of back when at rest. Chew. Example - beetles.

Lepidoptera: Scales on wings. Example - butterflies and moths.

Diptera: Two wings and two halteres (reduced hind wings). Suck or lick. Example - flies.

Siphonaptera: Flat body. Good jumpers. Wingless. Suck. Example - fleas.

Hymenoptera: Smaller hind wings hook into fore wings. Females sometimes with stingers. Example - wasps, ants, bees.

B. SORTING INSECTS BY HOW THEY LIVE.

Social Insects live in colonies with work of the colony divided among different castes of members. A colony usually consists of a queen, males (sometimes absent) and workers of various types.

Non-social insects live individually, pairing as needed for reproduction.

C. SORTING INSECTS BY HOW THEY EAT.

Insects with piercing and/or sucking mouth parts, e.g. aphids, butterflies, bees, lice, bugs, flies.

Insects with chewing mouth parts, e.g. beetles, grasshoppers, termites.

D. SORTING INSECTS BY WHAT THEY EAT.

Insects which feed on plants, either by sucking the juices or chewing the plants are called herbivores, or herbivourous, e.g. grasshoppers, aphids, bees, bugs, butterflies, moths.

Insects which feed on living animal tissue are called parasites or predators, e.g. mantids, female mosquitoes, sucking lice.

Insects which feed on dead animal tissue are called scavengers, e.g. some ants, some beetles.

Insects which feed on animal tissue, living or dead are called carnivores, e.g. praying mantids.

Insects which feed on both plant and animal tissues are called omnivores, e.g. some ants.

Some insects have special diets, e.g. termites, silverfish.

E. SORTING INSECTS BY HOW THEY EFFECT HUMAN BEINGS.

Insects which cause us harm personally are usually called pests. They cause harm:

-By hurting us with biting or stinging
-By carrying disease germs to us (Insect vectors)
-By pestering us, like ants or flies

Insects which harm the things we like or need, such as crops and domestic animals are also called pests. They cause harm:

-By sucking, chewing, causing disease in plant crops
-By sucking blood, causing disease, bringing disease to cattle, and pets

Insects which we consider helpful or useful to us are called beneficial. They benefit us:

-By making food for us (bees)
-By making other things we use (wax, cochineal)
-By getting rid of harmful insects (ladybird beetles)

F. SORTING INSECTS BY HOW THEY TREAT ONE ANOTHER.

Insects which live with other insects so that both species are benefited are symbiotic. The situation is called symbiosis. The symbiotic relationship may be between insect and insect, or between insect and another animal, or between an insect and a plant, e.g.:

-Insect with insect: Some cases of ants and aphids
-Insect with other animal: Termite and protists in its gut
-Insect with plant: Bees and flowers

Insects which capture and eat other insects are predators. The victim is called the prey, e.g.

Ladybird Beetles and Praying Mantids capture and eat any smaller insect.

Insects which live off the living tissues of other insects or of other animals are parasites. The victim is the host, e.g.

Uku's (lice) in human hair.

Concluding Remarks

Students usually tire of studying insects long before this entire book of insect topics is covered. It is wise to stop before interest lags. The topic can be resumed again at a later time or in a later year.

Teachers are reminded to consult the PROGRAM MANUAL under the heading of Longitudinal Records and fill out the names of those insect topics which have been taken during the year. This allows succeeding teachers to know which insect topics have already been covered in a previous grade.